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DESIGN AND OPERATION OF RADIO · FM · TELEVISION
RADAR AND ALL COMMUNICATIONS EQUIPMENT

January · 1947

Electronic Aids for Airplane Navigation — Status of Broadcasting Abroad · Effect of Sunspot Cycles on Long Distance Radio Signals · United Nations Broadcasting and Sound System Details

●

Light Beam Television Transmission Methods — Railroads Plan Increased Use of Radio for Communications · Multi-Channel Radio Telephone for Inland Waterways · Crystal Control for Receivers

●

Synthetic Spectrum Generator for Acoustic Tests · Shorting Gate Noise Suppressor · Paper Tape Magnetic Recorder · Design of 500 KC Transformers · Television Synchronizing Generator

●

Navy's Radar Friend-or-Foe Identification System · Engineering a 250 Watt BC Transmitter for FM · US Radio Statistics for 1947 · Metallized Paper Capacitors · Washington Newsletter

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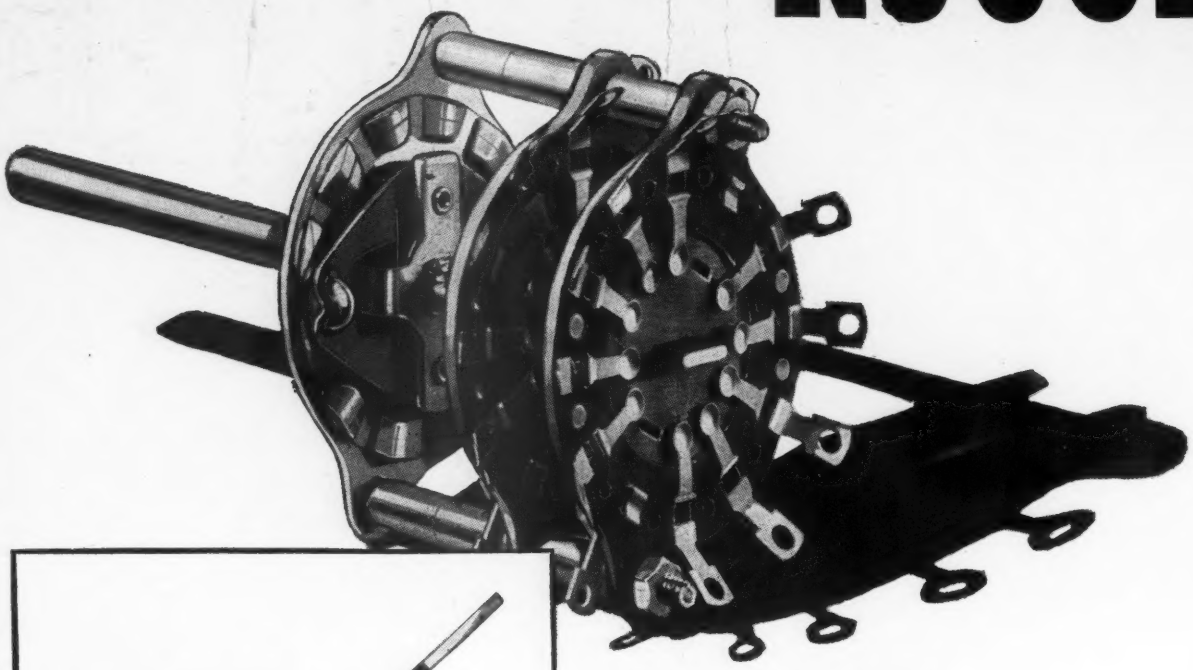

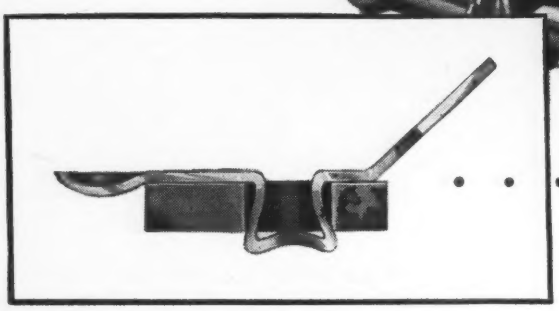

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Notice how the terminals are fitted right into the stator—firmly held without rivets or staples. No chance of their wobbling loose! The terminals, in turn, are solidly built of spring brass material which is heavily plated with silver. Notice, too, the high lift and flexing ability of the terminals. That's to provide a self-cleaning action, insuring better electrical contact.

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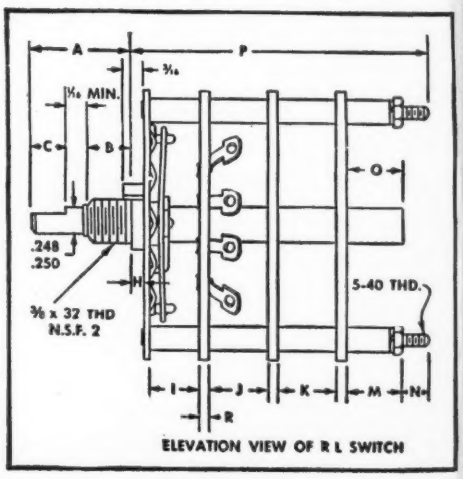
The RL Switch offers from 1 to 6 circuits per section with 30 degree indexing—from 1 to 3 circuits per section when 60 degree indexing is used. RL Specification Sheets will give you more of the story. Send for them without obligation. Call on our engineers *any time* for extra help.



ELEVATION VIEW OF R L SWITCH

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JANUARY, 1947

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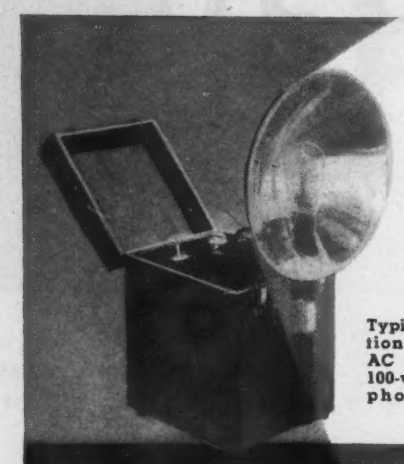

Typical discharge application—the "Syncroflash"—AC operated light-weight 100-watt-second high-speed photo-flash apparatus.

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50	1.8 " "	PX13D1	4-9/16 x 3¾ x 4⅝	4⅜
50	2.0 " "	PX14D2	4-9/16 x 3¾ x 4⅝	4⅜
100	2.5 " "	PX15D1	4-9/16 x 3¾ x 6½	6⅛
75	3.0 " "	PX18D1	4-9/16 x 3¾ x 4⅝	4⅜
550	3.0 " "	PX22F1	5⅛ x 13½ x 13	App. 64
100	4.0 " "	PX20D1	4-9/16 x 3¾ x 4⅝	4⅜
500	4.0 " "	PX32F1	5⅛ x 13½ x 13	63

*Stored Energy = ½ CE² Watts-Seconds (C in farads)

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O. H. CALDWELL, EDITOR ★ M. CLEMENTS, PUBLISHER ★ 480 LEXINGTON AVE., NEW YORK (17), N. Y.

More Power!

For AM, FM & TV

AM, FM and television are all having their reception difficulties.

Programs produced in the studio with faultless technical accuracy, still reach part of the public riddled by natural static, electrical "noise", and radio interference.

Elaborate customer-antenna installations are needed today in many localities for both FM and television. On the new FM "high-band", particularly, carefully engineered dipoles and downleads are essential in outlying locations, if the set owner is to enjoy the noise-free reception that should be possible with this great new service.

Video has its marring blemishes, too, as automobile ignition, foreign broadcasts, diathermy, and even FM, ride in to spoil perfectly-emitted station pictures.

Yet there is no interference difficulty which cannot be remedied by more power at the transmitter.

Power — and more power — is the answer to static, interference, and poor reception, all along the line.

Power at the transmitter means a simple receiver antenna — or, for many services, no antenna at all!

Power at the transmitter means home receivers of less complexity and expense.

Yet the tendency has been for governmental authority to hold back on power, rather than to increase it as is so distinctly in the public interest.

Abroad — where adequate station power is viewed as a merit rather than a misdemeanor — we see already over 100 broadcast stations of 100 kw and higher.

England has an 800-kw broadcast transmitter. The USSR has two or three 800-kw stations — and even a super broadcaster of 2500 kw!

Great Britain, with a land area only one-thirtieth of ours, has total BC station power nearly equalling that of the U.S.'s 1100 stations with a continent to cover—as revealed in tabulations on following pages.

Power at the transmitter can solve all reception troubles.

Radio engineers and the Federal authorities should work together to give the public new high standards of signal strength—on AM, FM and TV!

Large Four-Color Chart-Map Supplement Sent You with This Issue

"WORLD-WIDE TELE-COMMUNICATIONS MARKETS"

Broadcast Transmitters and Receivers — Powers, Numbers, Population Densities, Ratios of Battery-vs-Mains Sets, Imports

Analyzing Present Position of F

By GREGORY SHEA, Associate Editor, Tele-Tech

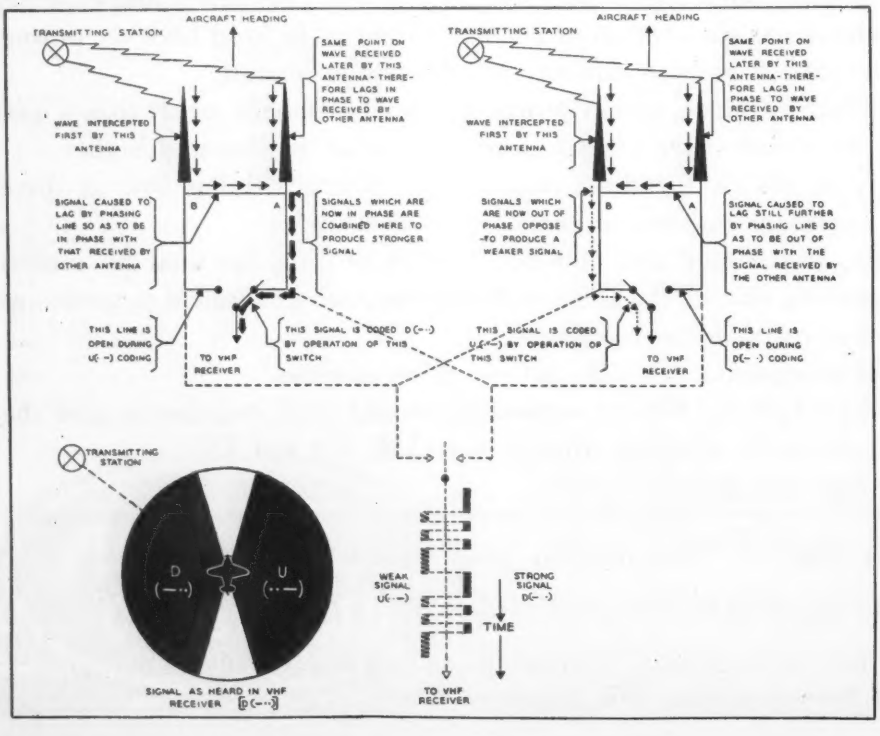
Solution of airplane traffic handling problems is the big task of the Provisional International Civil Aviation Organization (PICAO)

• Ask the average radio engineer about aircraft radio and navigation aids and he will throw up his hands in an admission of complete confusion. The multiplicity of systems, in use and proposed, and the many functions sought to be performed definitely have got him down.

To a degree, obviously, this is a reflection of the fact that the safe movement and control of a large volume of planes traveling at high speed over all the world is complex and difficult. Additionally, however, it is because no clear outline has been generally circulated showing what the various problems are and what solutions have been proposed.

IN view of the extreme importance to the electronic world of the decisions which will be reached at the Montreal world conferences, there is given here a grouping of the problems encountered in flight together with recommended electronic solutions which have been offered the PICAO delegates. Only solutions of great interest or which have been recommended for development and standardization or investigation by the Aircraft Radio Laboratory's Navigation Committee, (an Army body) are included.

VHF Homing and Right-Left Homing—General operating scheme and pattern of signals in airplane


TRANSMITTING STATION
AIRCRAFT HEADING
SAME POINT ON WAVE RECEIVED LATER BY THIS ANTENNA - THEREFORE LAGS IN PHASE TO WAVE RECEIVED BY OTHER ANTENNA
WAVE INTERCEPTED FIRST BY THIS ANTENNA
SIGNAL CAUSED TO LAG BY PHASING LINE SO AS TO BE IN PHASE WITH THAT RECEIVED BY OTHER ANTENNA
SIGNALS WHICH ARE NOW IN PHASE ARE COMBINED HERE TO PRODUCE STRONGER SIGNAL
THIS LINE IS OPEN DURING U(·–) CODING
TO VHF RECEIVER
THIS SIGNAL IS CODED D(–··) BY OPERATION OF THIS SWITCH
TRANSMITTING STATION
AIRCRAFT HEADING
SAME POINT ON WAVE RECEIVED LATER BY THIS ANTENNA - THEREFORE LAGS IN PHASE TO WAVE RECEIVED BY OTHER ANTENNA
WAVE INTERCEPTED FIRST BY THIS ANTENNA
SIGNALS WHICH ARE NOW OUT OF PHASE OPPOSE -TO PRODUCE A WEAKER SIGNAL
SIGNAL CAUSED TO LAG STILL FURTHER BY PHASING LINE SO AS TO BE OUT OF PHASE WITH THE SIGNAL RECEIVED BY THE OTHER ANTENNA
THIS SIGNAL IS CODED U(··–) BY OPERATION OF THIS SWITCH
TO VHF RECEIVER
THIS LINE IS OPEN DURING D(–··) CODING
TRANSMITTING STATION
D (–··)
U (··–)
SIGNAL AS HEARD IN VHF RECEIVER D(–··)
WEAK SIGNAL U(··–)
STRONG SIGNAL D(–··)
TIME
TO VHF RECEIVER

During the last few years civil aviation terminal conditions have been getting progressively more difficult. As the number of flights has increased it has become possible to handle them only during good weather. As soon as bad weather has come on and flying conditions have become overcast around a busy terminal airport such as LaGuardia field in New York, planes coming in to land have not been able to do it fast enough to get out of the way of new arrivals.

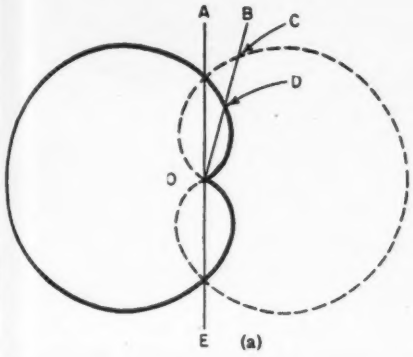
As a result, with numerous planes flying around, it becomes necessary for the control tower at the airport to order vertical separation, that is, each plane is given an altitude level at which it must fly until it can land. Other new planes coming into the area are held at outer locations and may also have to be stacked vertically. It is obvious that the saturation point comes very quickly and it becomes necessary to order points of departure not to permit any more flights to start for LaGuardia.

While this landing problem is one of the most serious confronting civil aviation, as it results in the loss of millions of dollars in revenue annually, other problems connected with flights also have become troublesome as traffic density has increased.

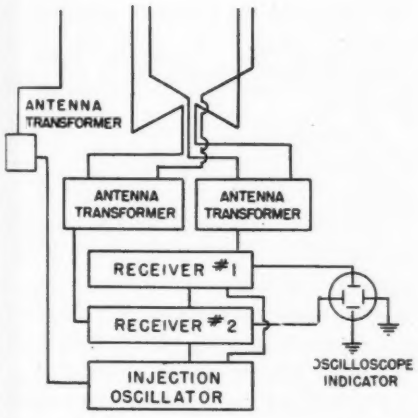
To mention one other one, planes now are being used which fly 180 miles per hour and others which fly 400 miles per hour. Suppose the latter overtakes the former on an airway! What happens in a cloud!

Or again, the present land navigation equipment used gives four

Electronic Aids for Airplanes

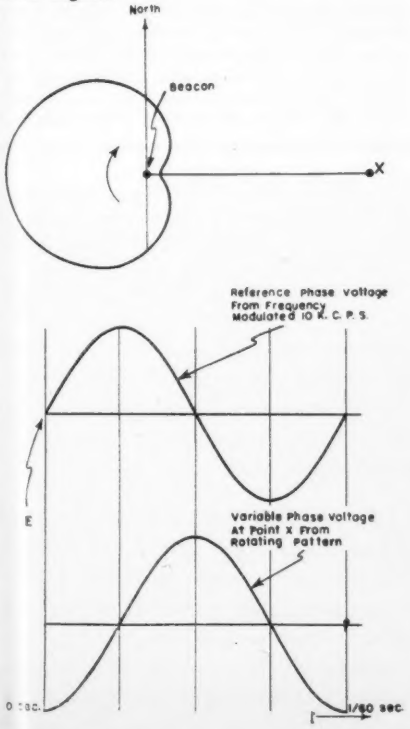


Airborne A.D.F.—Cardioid antenna pattern which varies signal strength when switched over



Ground D.F.—Layout using 'scope indicator

CAA Very High Frequency omni-range. —Pattern rotates 60 rps and is referred to non-rotating 60 cycle modulated circular signal.



AN ranges along which planes can fly toward or away from an airport. Suppose a plane is forced considerably off a range so that the pilot no longer can hear the A or N signals. How does he know where he is?

To solve these and other similar problems a number of extremely ingenious electronic devices have been designed, built and tested by private organizations and by government departments both here and abroad, principally in England. Many of them have come out of the war with ground installations already made to provide reference signals. Such installations represent heavy investments.

Unfortunately many systems have been started. National pride is involved in some, as well as profit considerations — control of manufacturing—national safety interests.

But to any person interested in world-wide airline service it is obvious that not only efficiency and economy but even the very existence of free world girdling services depends on uniformity of equipment. No airplane can carry equipment to navigate by three or four different methods depending on whether it is flying over the U.S., England, the continent, Asia, Africa or South America. Weight considerations alone, not to mention personnel training difficulties, would prohibit it.

To try to arrive at an acceptable compromise on these questions and to secure some plan of standardization, the Provisional International Civil Aviation Organization, nicknamed PICAO, has been created.

Foreign Delegations

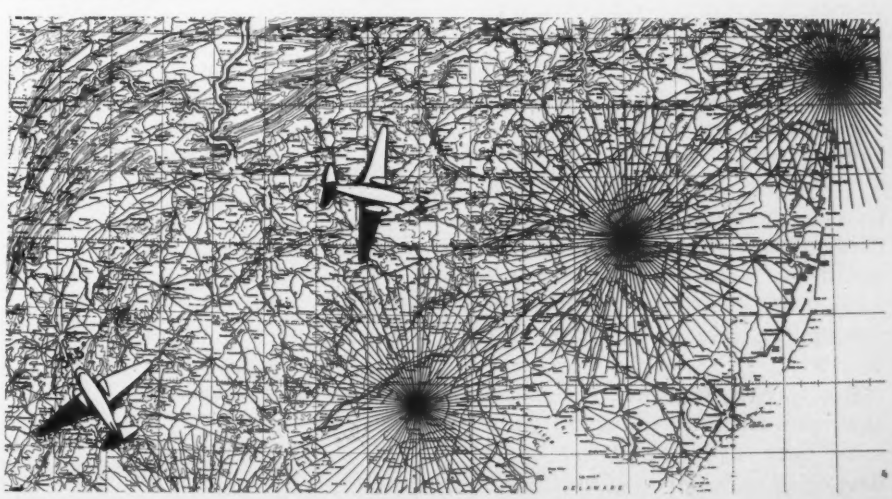
To get a program started the Civil Aeronautics authority, the State Department and representatives of the British Government invited delegations from all the countries of the world interested in aviation development to come first to England where a very complete demonstration was given them of all apparatus and systems suitable for standardization and offered by the British.

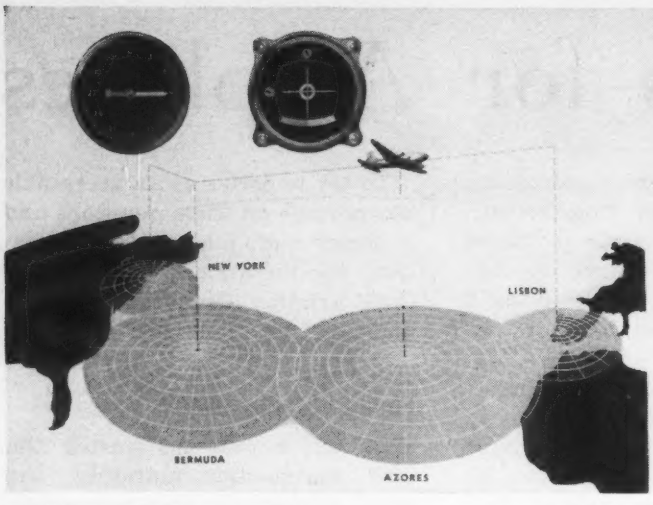
Following this meeting the delegates all came to the Civil Aeronautics authority experimental station in Indianapolis to go through a two weeks' course of demonstration of the equipment offered by Americans.

With the completion of both of these demonstrations the entire delegation has proceeded to Montreal for a session of deliberations designed to obtain agreement on the adoption of as many systems, instruments and procedures as possible. As this is going to press, some results of the Montreal Conference are reported on page 102.

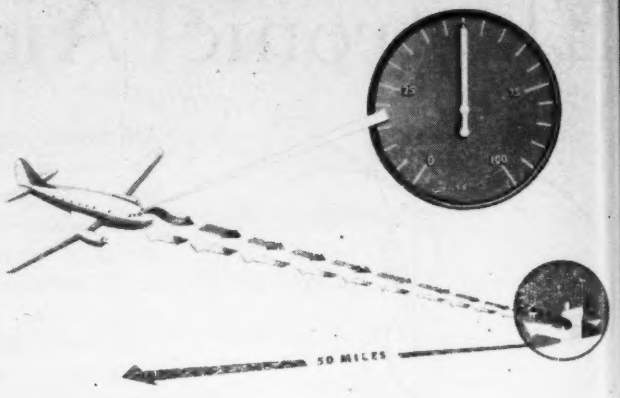
There is no doubt that whatever systems are finally adopted, there

VHF omni-range beacons on the Washington to New York run. Free from low frequency faults





CAA Low Frequency omni-range beacon layout on New York to Lisbon run. Indicators shown above



G.E. pulse DME system—Plane signal is returned by ground beacon and time delay measured

will be opened up an enormous field for the development, manufacture and installation of ground and airborne electronic equipment.

Interested persons should realize, however, that while the various problems connected with medium and long distance navigation appear to have been solved fairly well from a continuous operating point of view by any one of several systems and aids to navigation, many PICAO delegates do not feel that this is the case with respect to terminal handling systems.

They feel that this is the central problem of the future development of high density air traffic. They also feel that the solutions so far proposed are limited in their traffic handling capabilities by the loads they impose on the human brain. This applies not only to the pilot in the cockpit but to the controller in the terminal tower.

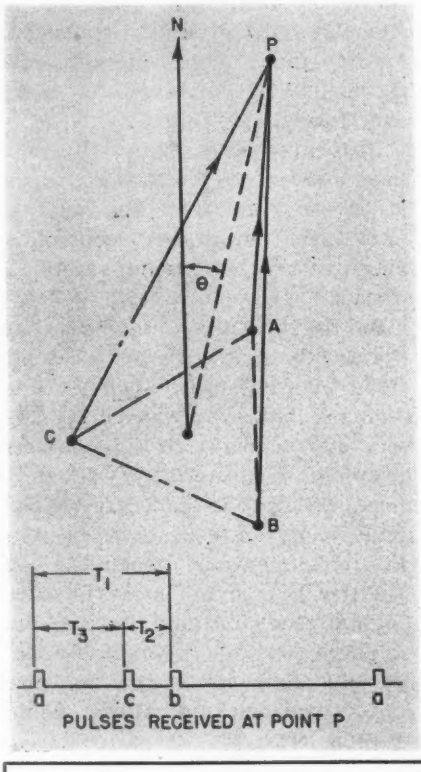
For example, several systems are designed to give pilots quite complete pictorial information of other planes, ground stations, altitudes, etc. Many informed persons feel that the pilot simply can't handle that much information when he also has all the flying problems to contend with.

The same is true in the control towers where even the most logical presentation on automatic register boards or large projected maps of high traffic density would mentally swamp the best ground controller ever born.

However, everyone recognizes that the airplane industry, which some time ago passed out of its first or barnstorming phase, is now passing from its second or romantic phase to its third or New York subway phase. It must then be close to 100% reliable or it will not grow up.

A new proposal by the well-known engineer, S. Young White is that automatic air tracks be created by intersection of microwave beams radiating at acute angles along the sides of airways. Incoming planes would latch on to such tracks and no further mental effort would be required by the pilot.

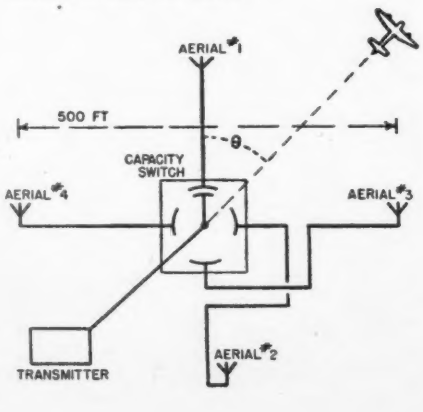
Probably some such solution will constitute the final answer since at peak rush hours it is anticipated that three airports in New York will have to handle one plane per minute per runway!



United Kingdom omni-pulse range; three stations A, B and C transmit pulses synchronously. Variation of received time on plane causes selsyn to show direction. Time relationships vary in a sinusoidal manner in accord with azimuth

Electronic Navigation Aids Classified

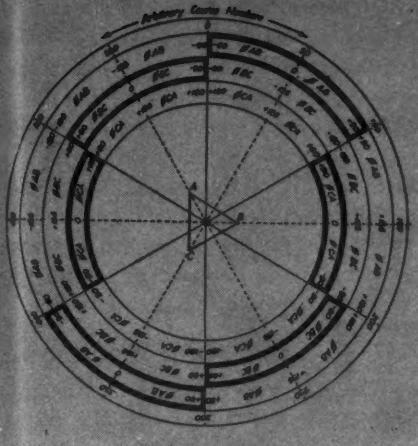
United Kingdom omni-pulse range—pulses are consecutively switched from one antenna to another. Three or four antennas may be used



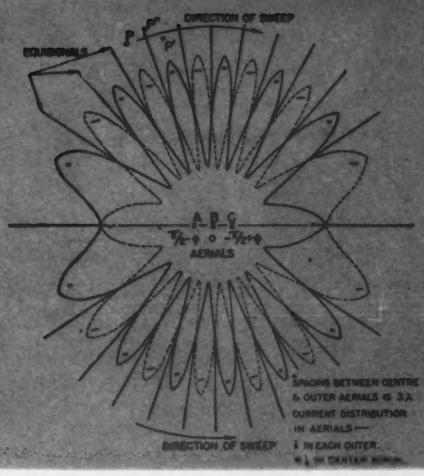
HOMING SYSTEMS

As their name implies, these are simply direction finding devices giving an indication of the direction of arrival of radio energy. They are in wide use in aviation, particularly long range flying, where they serve instead of radio ranges.

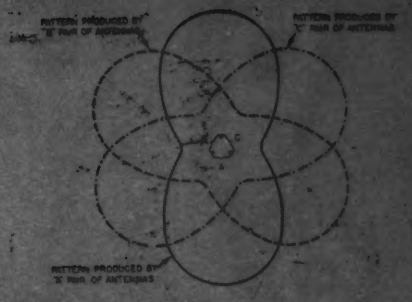
Airborne A.D.F. — A number of equipments are available. They consist of a loop antenna and a non-directional antenna which together give a cardioid pattern. By switching the pattern 180° a variation is obtained when the loop is



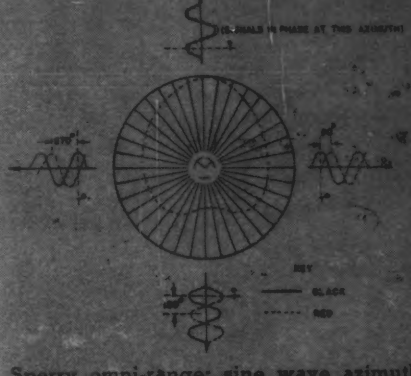
POPI—Antennas A, B, C transmit dashes in rotation while a fourth antenna gives a constant heterodyne signal. Phases are compared in plane



Consol (Sonne)—Three antennas fed as shown produce the full line pattern. By reversing phase in A and C the dotted pattern results. One lasts 1/8, the other 3/8 sec. Observer at P' hears 1/8 sec. dots, at P, 3/8 sec. dashes, at P" a steady tone. Also the phase is altered uniformly so that after 30 sec. the dot and dash patterns are interchanged. Dots are counted to obtain position as starting equi-signal lines are known



Navaglobe System—Pairs of antennas are fed successively to give 3 energy patterns. Signal strength from each pattern is used in ratiometer



Sperry omni-range: sine wave azimuth radiation of rotating antenna is compared in receiver with fixed phase of radiated signal

mis-oriented. Can be used on signals from 100 to 1750 kc.

VHF Homing and Right-Left Homing—This operates at 120-140 mc. Two rod antennas are used ¼ wave apart giving phased signals. Aural signals "U" (turn to right) and "D" (turn to left) are heard. Equipment is light in weight.

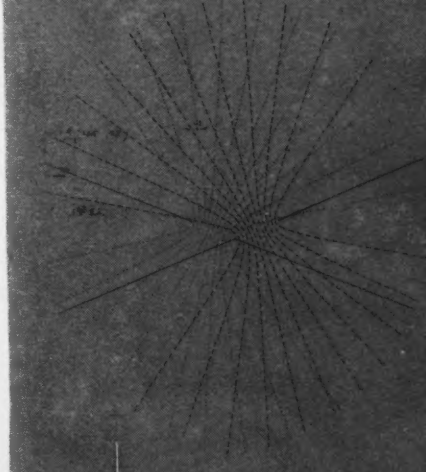
Ground D.F.—These are ground stations which determine the direction of airborne transmitters by well-known sense antenna methods. A number of variations are possible.

RADIAL TRACK SYSTEMS

Navigation by following radio tracks or ranges has been standard practice for a number of years. The tracks used most universally now are the low frequency four course AN ranges. These suffer from faults, bends, splits and cover usefully only a small portion of the area around any objective. Some omni-directional very high frequency ranges have been installed in the United States, notably on the New York to Chicago route. These give indications all around the compass and are in a frequency band substantially unaffected by the difficulties mentioned above for four course ranges.

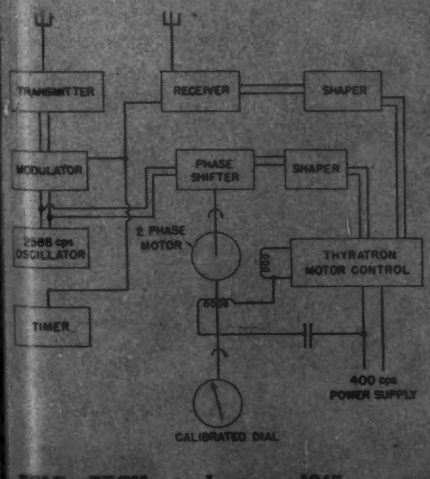
CAA Very High Frequency Omni-Range—This is a 125 mc system based on the use of a rotating directivity pattern modulated 60 cps as it rotates. A reference 60 cps time modulation also is emitted and the two are compared, giving azimuth all around the beacon.

CAA Low Frequency Omni-Range—Operates on same general prin-

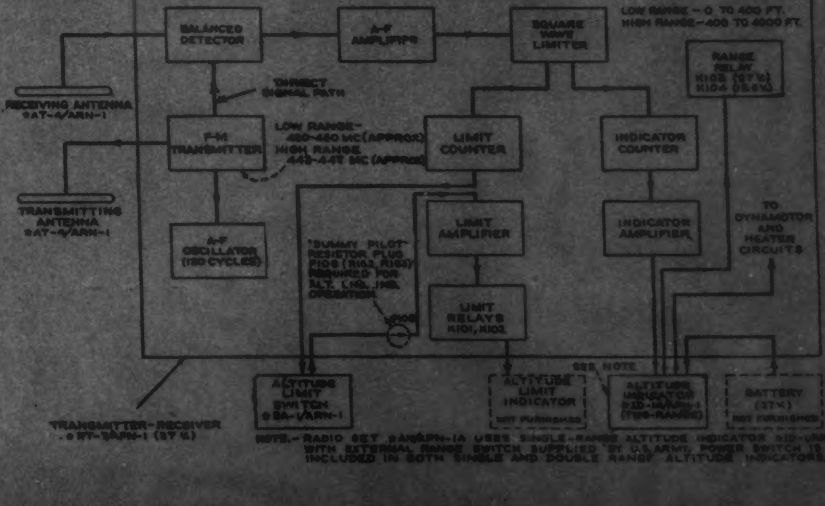


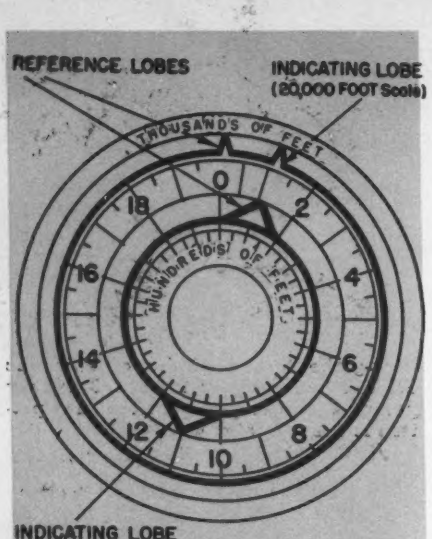
Loran: intersecting constant delay loci

ARL phase comparison DM system—Block diagram

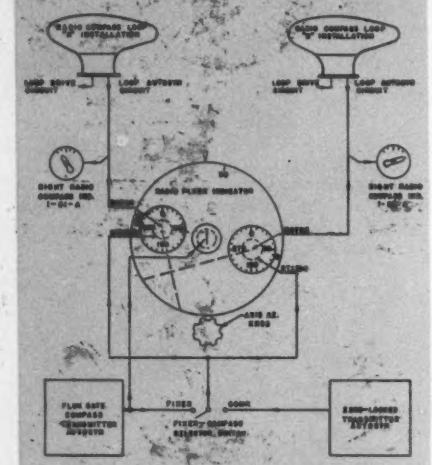


Radio Altimeter (Low Alt.)—Block diagram





Radio Altimeter (High Alt.)—Aircraft Indicator



Duggar Radio Fixer—Operational block diagram

ciple as VHF omni-range, but is designed for medium distances, having a 200-400 kc frequency.

United Kingdom Omni-Pulse Ranges—Two stations about three miles apart radiate, respectively, a master and slave pulse at the rate of 100 pulses per second. A fixed time delay is built in. Planes receive these two pulses and fly a constant delay line. Another scheme uses three aerials and switches pulses from one to the other, producing a phase change which is used to make amplitude variations in the plane, depending on its position. A third scheme is a pulse variation of the CAA omni-range, producing pulses whose time relationships vary sinusoidally with azimuth.

Consol (Sonne)—A rotating loop and a sense antenna are operated together on the plane and actuate a pointer showing signal direction. A special means is used to overcome phase shift errors. This is a long range system having great promise.

Navaglobe System — A low frequency very narrow band system for long range direction finding featuring great reliability. A CW omni-range. Three antennas are used and energized successively giving separate energy patterns.

Woodward Omni-Range—Closely resembles the CAA low frequency omni-directional range.

Sperry Omni-Range — A 12 cm system using a rotating antenna and a non-rotating reference phase radiation. Azimuth is determined from phase comparison.

TIME DIFFERENCE

Several of these system were in use both here and abroad during the war. Basically these are purely navigation systems designed to permit the pilot to determine his position fairly exactly with reference to ground stations of known location.

Loran—Receivers are sensitive to 1.95 mc pulses emitted from pairs of masters and slave ground stations. A plane nearer one of a pair of stations receives its pulses before those of its mate. A cathode ray tube is used to display the receiving time difference. Marker circuits are used to obtain exact time differences. Lines of constant time differences are hyperbolas and are plotted on special charts. Distance range over land is poor. Equipment requires skilled operation.

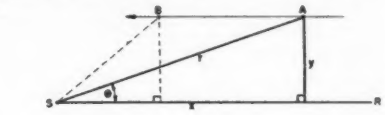
Australian Multiple Track Radar System—Uses a frequency of 225 mc. In the plane the time interval is tracked automatically and appears on a meter. A few miles out, the hyperbolic tracks became practically radial straight lines.

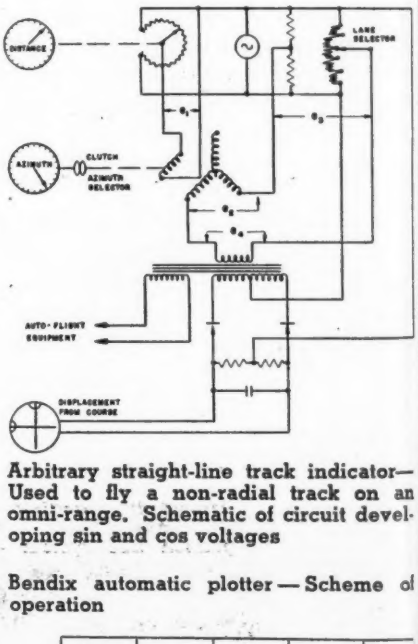
In addition three British hyperbolic systems have been considered but not recommended for standardization. Gee is a system having four sending stations. Hyperbolic grids give lines of constant time difference for the airborne reception of pulses from pairs of these stations. Special equipment aloft and special ground stations are needed.

POPI (Post Office Position Indicator) also uses four antennas at the corners and center of a triangle. These transmit in rotation. Points equidistant from two stations receive in-phase signals from them. At other points the signals are out of phase. This phase difference is measured. This system has not been used, being in the development stage. Decca is also a phase comparison system. Presentation is by an integrating phase meter.

DISTANCE MEASURING

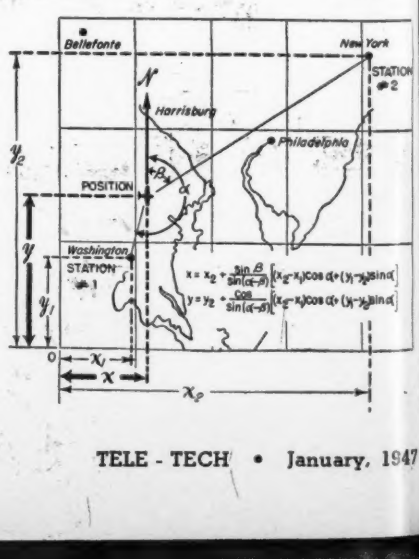
When a plane is flying through thick weather with variable winds or is approaching a busy airport location, it is of extreme importance to the pilot to know how far he is from his destination, or from an obstacle or above the ground. Systems have been proposed to solve this question. Recommended requirements are that there should be 46 channels, each accommodating 50 planes up to 100 miles dis-

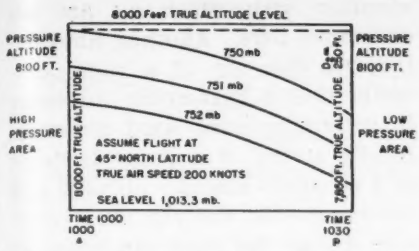




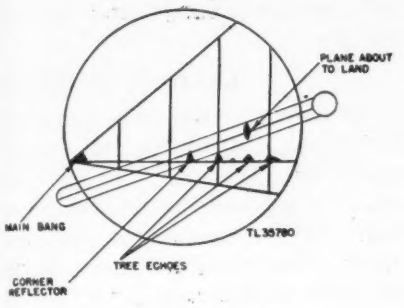
Arbitrary straight-line track indicator—Used to fly a non-radial track on an omni-range. Schematic of circuit developing sin and cos voltages

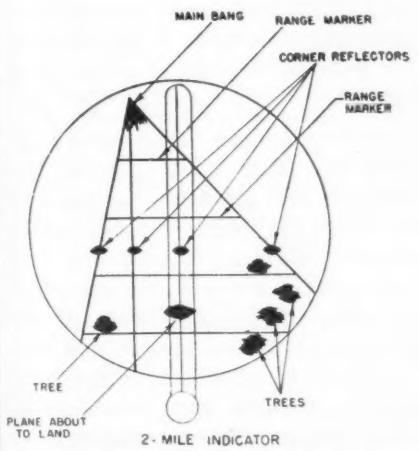
Bendix automatic plotter — Scheme of operation





Computing system—Radio altimeter and barometric altimeter are used together to obtain wind drift





GCA System—Glide and azimuth 'scope indications

tant. The data should be usable for automatic flight and with runway localizers. Beacons should be coded.

G.E. 1000 mc Pulse DME Systems—A radar system with a ground reply beacon which will give distance, possibly direction and rate of approach. May permit orbiting of airplane around beacon.

ARL Phase Comparison DM System—A 2588 cycle audiotone modulates a carrier and is sent from the plane to ground beacon. The latter retransmits on a different carrier. The plane receives and detects the ground signal and compares the phase with original phase. Range 36 miles at above audio frequency.

Radio Altimeter (Low Alt.)—This is a terrain clearance indicator operating on FM emitted groundward. A reflected signal is combined with the emitted signal to produce an audio voltage proportional in tone to altitude.

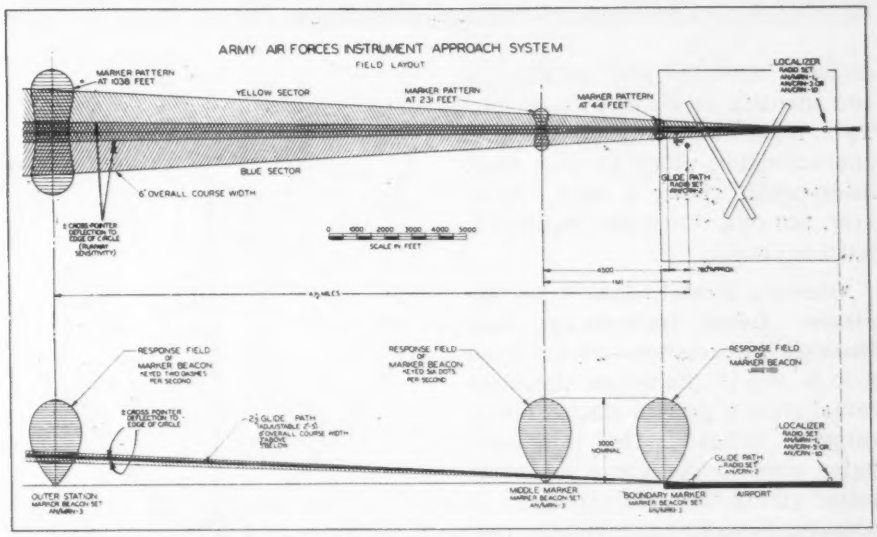
Radio Altimeter (High Alt.)—This is a radar system with a J or circular scan.

PRESENTATION SYSTEMS

Several schemes to simplify the pilot's job of interpreting information and finding his chart position have been developed. These should be classed as aids to navigation.

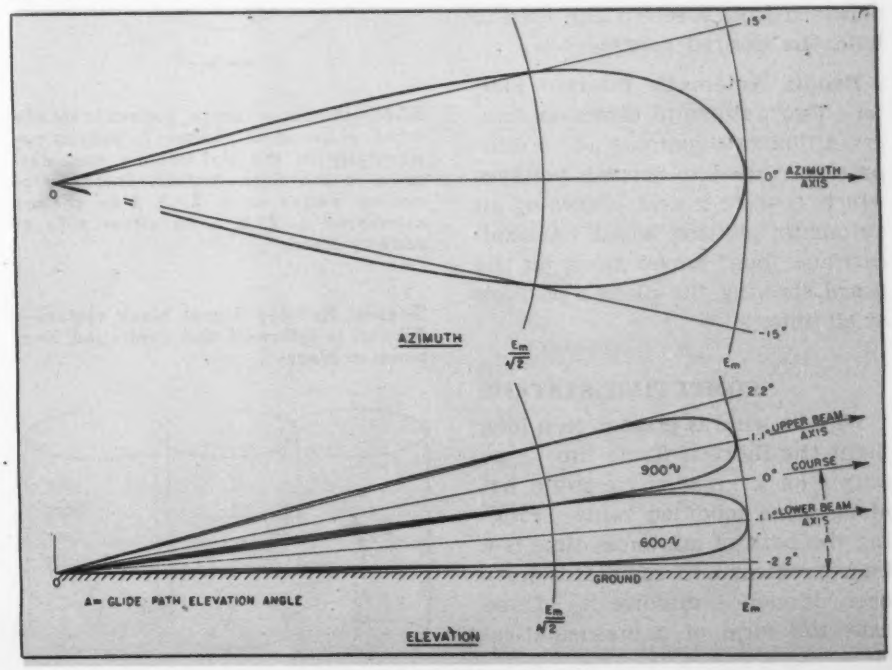
Duggar Radio Fixer—This is a medium distance aid consisting of a translucent circular screen upon which special maps may be mounted. Lightbeams originating from two points on the map, which represent the location of the radio stations, are used to show the azimuth locations of the plane. The intersection of the beams provides a fix. Airplane heading is shown by a small needle in the center. Automatic radio compasses, a flux gate and an autosyn operate the fixer. Accuracy depends on radio compass accuracy.

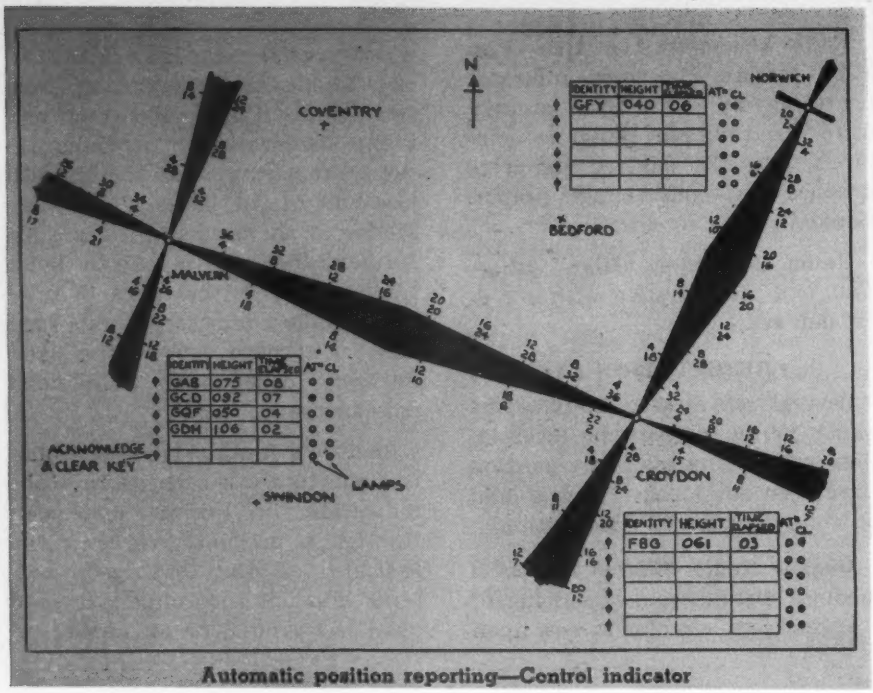
Shearer's Radio Visor—The pilot is made to see a cathode ray tube indication in third dimension through a prismatic viewer. The indication is that of beacon patterns laid out according to a plan upon the ground or an airway in-



Instrument landing system—Field layout showing position of markers, glide path and course locator

Sperry microwave system—Glide path antenna patterns. Ground reflections not used





Automatic position reporting—Control indicator

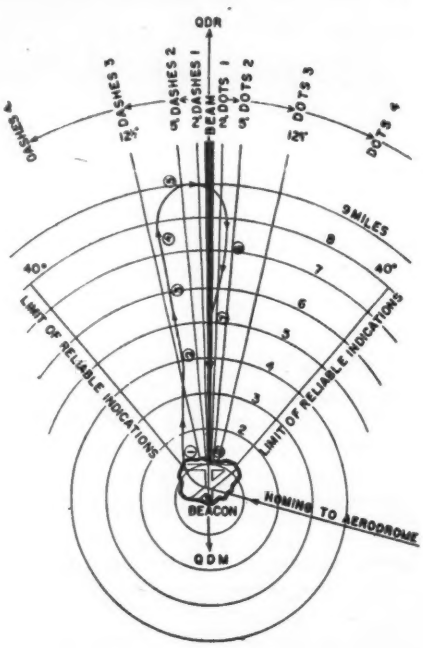
dicating direction and distance to and identity of an airport or city. Two antennas with sharp null characteristics would be used, their intersection giving a spot. However, the null sharpness required is hard to obtain.

Arbitrary Straight-Line Track Indicator Using Omni-Range and Distance Information—Flying from A to B, two points not on the same radial from a ground station omnirange is difficult. This is a computer used to operate a left-right meter giving the line required. It operates by taking the voltage representing distance from a distance measuring equipment. Sine and cosine values of this voltage are obtained from a selsyn and used to hold the desired course.

Bendix Automatic Position Plotter—Two automatic direction finders, a flux gate compass and a computer are used to furnish voltages which operate x and y axes of an automatic plotting board. A small carriage "bug" moves along on the board showing the plane's position at all times.

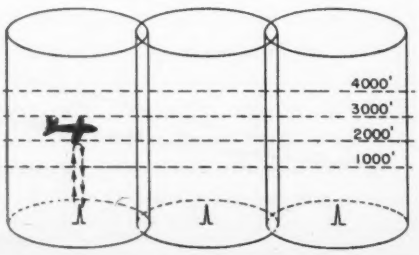
COMPUTING SYSTEMS

When a wind is present on a long flight the shortest flying time is no longer on a great circle route but along some modified route. Finding the path of minimum time is a hard problem and some aids have been developed to solve it. These take the form of a mathematical



BABS—Airborne 'scope pattern is steady when plane is on course. It widens periodically in the dot sectors and narrows in the dash sectors. Intensity of coding varies as 1, 2, 3, 4 in sectors numbered 1, 2, 3, 4 on either side of runway beam

General Railway Signal block system—Aircraft is followed and controlled from block to block



equation with which we are not concerned here. Another, however, involves the use of a radio altimeter and a barometric altimeter to determine cross wind direction. Briefly stated, if a plane is flown at a constant absolute altitude and the barometric altitude rises (pressure drops) the pilot can conclude a wind has been blowing him to the left (in the northern hemisphere) at a speed proportional to the pressure change and to his latitude.

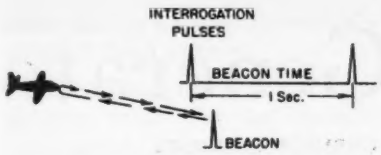
LANDING SYSTEMS

The need for these schemes is so obvious as not to require discussion. The types proposed are the use of radar and the creation of a flight path by means of radiated waves. The Navy has been using the radar GCA system for its Naval Air Transport Service and has a record of no flight cancellations for weather reasons. The CAA has developed the glide path and localizer systems and claims it can be used for automatic landing where GCA cannot.

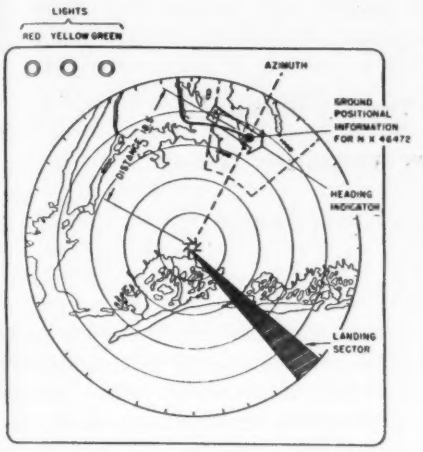
GCA (Ground Controlled Approach)—This system shows the azimuth and elevation positions of an incoming plane on two radar scopes. Movable transparent hair line cursors are used by operators to follow the plane's flight. If the plane deviates the pilot is told how to correct his approach by the "talk down" operator over the regular voice communication equipment.

Instrument Landing System—Manual and Automatic (CAA)—In this scheme a localizer radiates a sharp vertical beam and a glide path radiates a sharp nearly horizontal beam with a 2½° slope. The pilot has a left-right and up-down meter which he keeps centered, thus following the path to the runway. In addition, vertical radiating markers operate lights and give coded sound at the end of the airport, one mile out and 4½ miles out. By taking the cross pointer meter voltages and applying them to an auto pilot, completely automatic landings can be made.

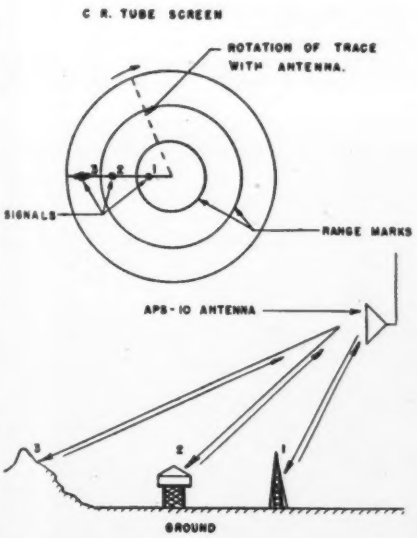
Sperry Microwave System, Manual and Automatic—This is also a localizer and glide path system but uses frequencies near 3000 mc. This permits creation of sharper and more easily controlled beams. Here,



Air-to-air collision warning — General operation



Sperry air traffic control system—Possible indications available aboard the aircraft



Airborne radar detectors — operating scheme

as in the CAA system, cross pointer voltages may be used to operate an auto-pilot.

BABS (Blide Approach Beacon System)—An airborne interrogator is used with a ground transponder beacon. Provides a constant signal strength beam down the prolongation of the center of the runway. Strength varies periodically at all other positions. Pilot can also tell distance from end of runway.

Automatic Position Reporting—An interrogator responder scheme with automatic reporting initiated by strategically located beacons.

COLLISION WARNING

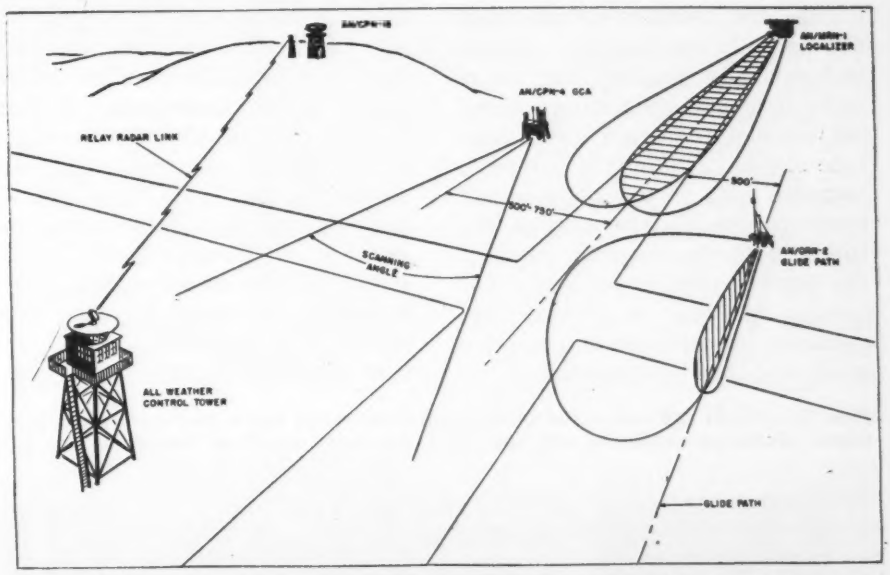
As a class, the systems and devices mentioned in this category have received little if any traffic operating trials. They have been called into being as a by-product of the necessity of surveillance of congested air spaces and of the desire of manufacturers to make use of war learned radar and IFF (Identification, Friend or Foe) technics. Undoubtedly this field of activity is of great promise both for airline and electronic interests.

General Railway Signal Block System—This is a scheme based on railway block signaling. It uses pulse interrogation and reply technics, assigning for surveillance a portion of airway to each of a string of ground stations.

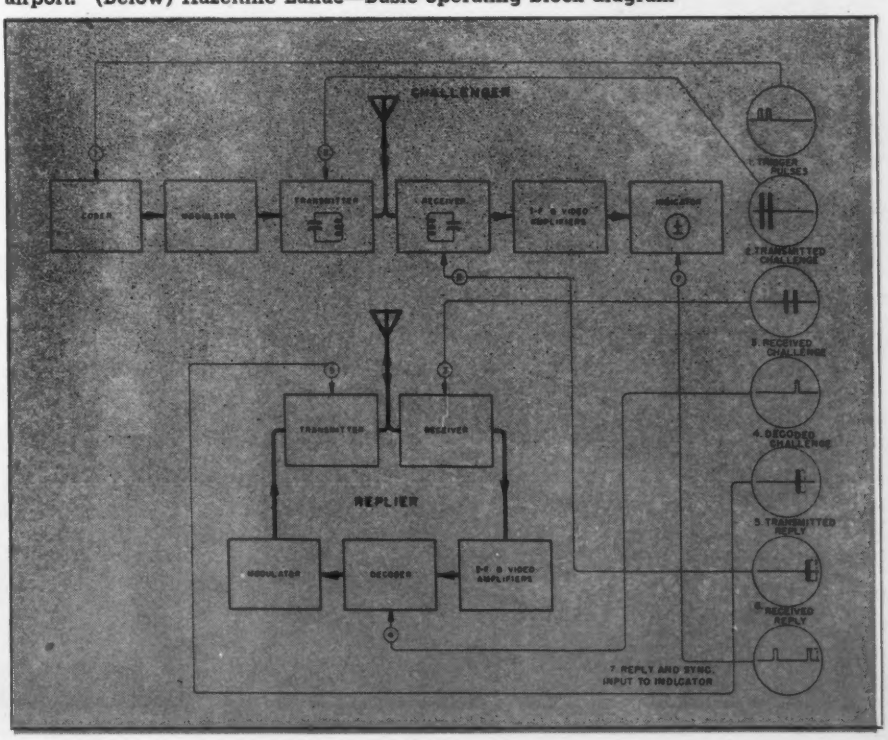
Air to Air Collision Warning (One Shot)—For a short time each second the equipment would interrogate and measure distance. During the remainder of the second it would act as a beacon for other aircraft. Altitude coding would be used in both transmitter and receiver.

Ground Surveillance Radar—This proposal includes the use of long

(*Continued on page* 134)



Air traffic and navigation system—arrangement of various radars and beacons at airport. (Below) Hazeltine Lanac—Basic operating block diagram



Synthetic Spectrum Generator for Acoustic Tests

By CARLTON E. BESSEY
Squier Laboratory,
Fort Monmouth, N. J.

Laboratory setup permits compounding of up to twenty standard frequencies for simplifying amplitude/frequency response tests

• Performance testing of microphones and headsets in quiet conditions or in conditions of intense ambient noise requires the use of audio frequency generators possessing unusual frequency and amplitude stability. Standard frequency response tests on microphones and receivers requires the manual setting of both the frequency dial and the level control of an audio frequency oscillator at twenty frequencies, for determining point-by-point response characteristics.

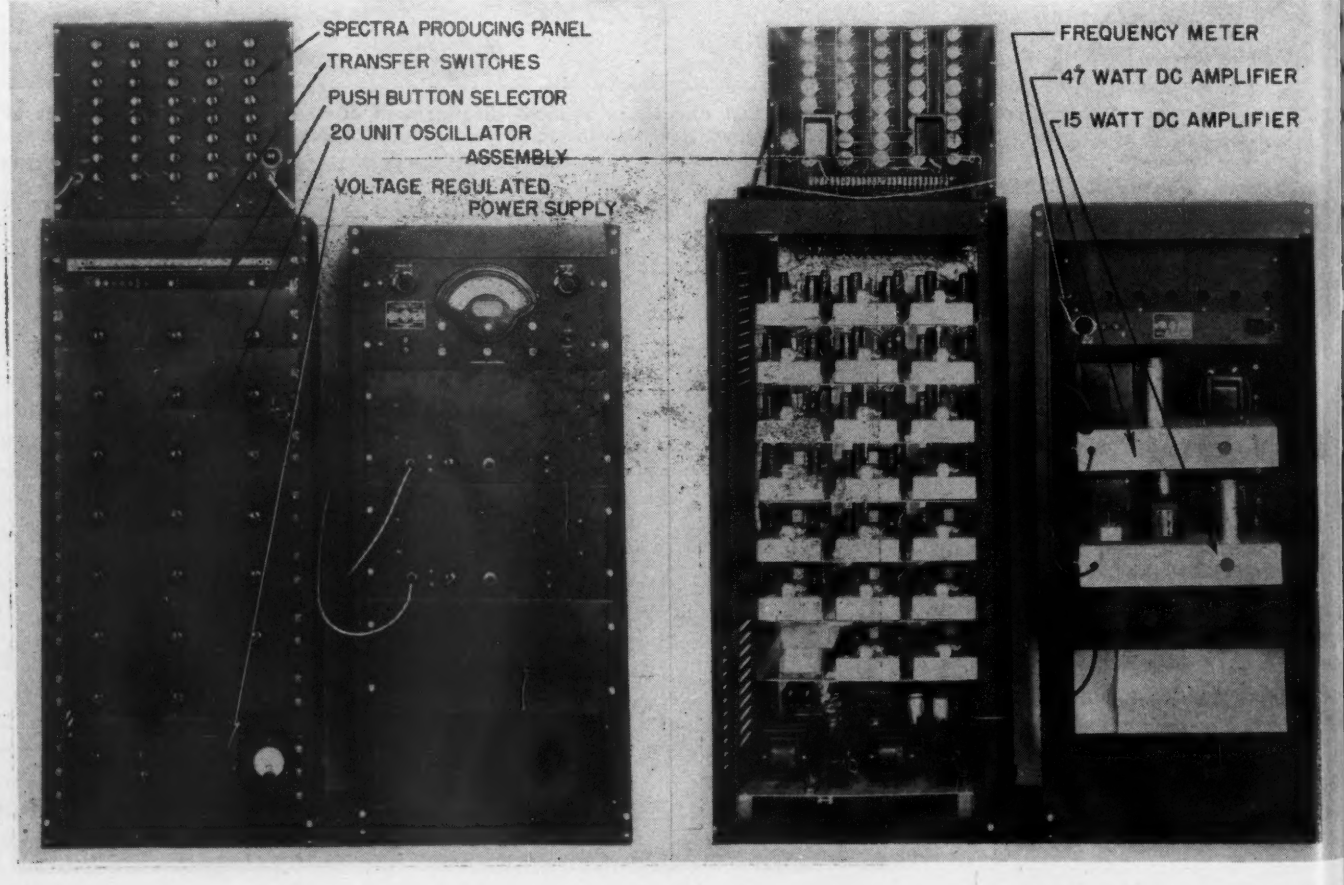
Factual evidence has proved that the dial calibration of various oscillators, commonly used for this test is not accurate over the entire range of the instrument. It has been found that inaccurate setting of the dial by the operator, caused by fatigue and lack of time due to the urgency of meeting deadline dates for the completion of these tests, induces errors which make it difficult to obtain the same test results at a later date.

In order to eliminate these difficulties the need for the design and development of new test equipment became apparent. The needed new equipment had to provide features not possessed by test equipment commonly used for these tests. These features are:

1—A compact individual unit generator for each of the twenty required frequencies.

2—Each unit to feature crystal control to attain frequency stability.

Figs. 2, 3—Front and rear views of the crystal-controlled audio frequency generator and amplifier assembly developed for testing Signal Corps microphones and receivers; an audio spectrum containing up to twenty selected tones can be synthetized



3—Each unit to contain its own individual level control.

4—The inclusion of a pushbutton selector array for the instant selection of the output of any of the twenty unit generators.

5—All twenty generators to be supplied with power from a common voltage regulated power supply in order to insure maximum signal level stability.

6—The complete equipment to be mounted in a small movable rack in order that it may be utilized in different parts of the laboratory.

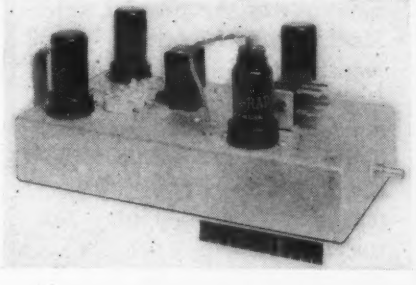
Since it is often necessary to perform tests on equipments under conditions of simulated ambient noise, such as encountered in a tank or aircraft, it is desirable to combine up to twenty single frequencies, to produce the required noise spectrum, and at the same time to provide another spectrum containing the energy characteristic of speech. To incorporate the dual spectra producing feature, the new test equipment was designed to include a dual channel mixer panel for mixing twenty frequencies, each channel incorporating decoupling networks to eliminate interlocking action.

Two crystals, whose fundamental frequencies are in the radio frequency spectrum but differing from each other by a frequency in the audio spectrum are used as a means of producing the required signals. Each crystal is connected to a vacuum tube by means of a Pierce circuit. (Fig. 1).

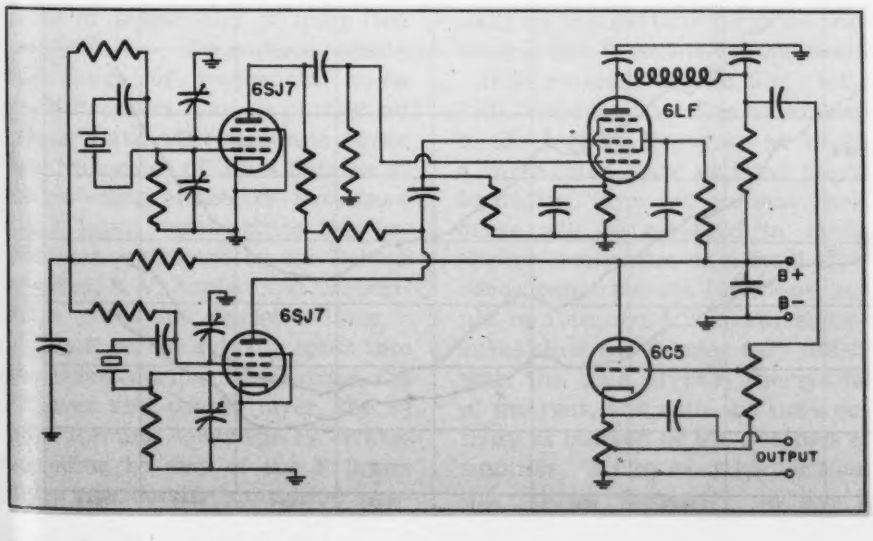
The output of these tubes is connected to a mixer tube, which is in turn connected to an amplifier tube, featuring a cathode follower output circuit. The suppressor grid of each of the crystal oscillator tubes provides a shield between the oscillation elements of the tubes and the output circuit, thereby reducing capacitive coupling between the two oscillators. In the same manner, the screen grid element of the mixer tube acts as a shield between the two input signals. This circuit design eliminates the synchronizing effect usually experienced with the beat frequency oscillators of similar type.

The output circuit of the mixer stage is provided with a radio frequency filter network to eliminate the fundamental frequencies of the oscillator stages from being impressed on the grid circuit of the cathode follower output and hence appearing in the audio frequency output circuit.

Since the vacuum tubes receive power from a voltage-regulated supply, the heat generated is constant. The crystals are located in a position to utilize this heat for an "oven effect" to aid in maintaining frequency stability. The crystals used in this equipment are cut in a manner to assure that the frequency drift of each crystal would be in the same direction for a given change in room temperature, thereby guaranteeing no appreciable change in the audio difference frequency.



Figs. 4, 5 (above)—Front and bottom view of an individual crystal control audio frequency generator unit. Fig. 1—The circuit used in each of these units



Regulated Voltages

The voltage regulated power supply has four type 6L6 tubes in parallel (triode connected) as current tubes, grid controlled by a 6J7 tube in the conventional manner. The voltage output from this unit remains substantially constant at 250 volts with line voltage varying from 90 to 130 volts. The filament heating current is obtained from two 6.3 volt 10 ampere transformers connected in parallel and connected to the 110 volt line through a voltage regulator.

A strip containing twenty SPDT toggle switches, located just above the pushbutton selector array connects the output of each of the unit oscillators to a corresponding pushbutton or to two controls located on the mixer panel. The mixer panel containing forty controls with associated decoupling networks makes it possible to set up two spectra simultaneously. Either of these spectra may be instantly selected by means of DPDT deck switches mounted on the mixer panel. Provisions are also provided in order that both spectra may be utilized at the same time, which facilitates "signal to noise ratio" testing technics.

Experience with operation of the model oscillator confirmed the calculated frequency and amplitude stability of operation expected of this device. Twenty identical unit generators (Figs. 4 and 5) were constructed, and installed in a rack. These units automatically make connections to the power supply and mixer circuits by means of

(*Continued on page* 132)

Effect of Sunspot Cycles on

By DR. HARLAN T. STETSON, Massachusetts Institute of Technology
Suburban Laboratory, Needham, Mass.

Correlating ionization effects and sunspot numbers permits anticipating field strength levels and critical frequencies

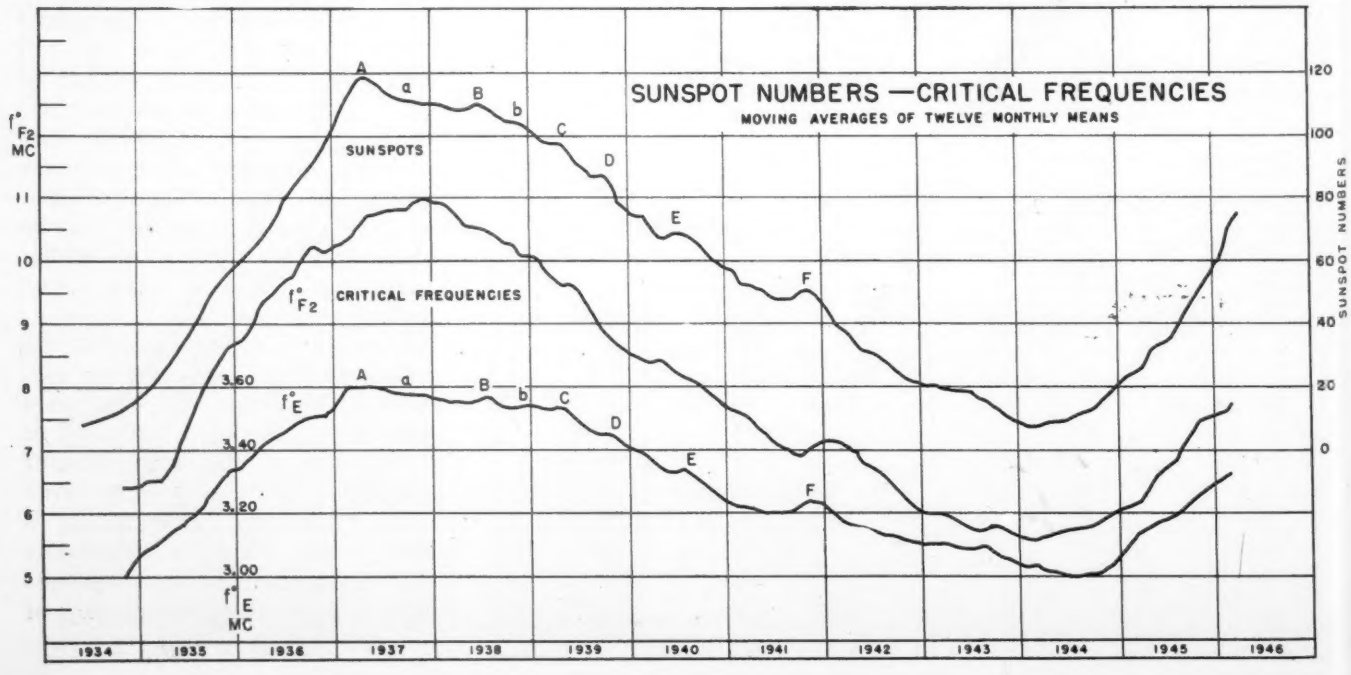
• Radio engineers concerned with long distance transmission are well familiar with the gradual change in workable frequencies over given paths through the course of the years in the solar cycle. Optimum workable frequencies as well as maximum usable frequencies over given areas bear a definite relation to the ionic or electronic concentration at the reflecting layers from which sky waves are returned to earth. The refraction or bending of the transmitted wave in the ionized layers is a function of the index of refraction at the layer of reflection which in turn depends upon the degree of ionization present.

Electronic engineers recognize certain stratifications, or ionized layers, in the atmosphere from which the sky waves of radio are reflected back to earth, thus making long-distance communication possible. The height of the layer at which the sky wave is returned to earth depends upon the frequency or wavelength of transmission. In the illustration, Fig. 1, the three well-recognized layers of concentrated ionization are designated as the D, E, and F layers.

THE problem of predicting in advance suitable communication frequencies for a given path is one of the most urgent tasks in radio communications at the present time. Much can be learned from measuring hourly values of the so-called "critical frequencies." This is now being done at an increasing number of ionospheric stations scattered throughout the world.

The D layer at a height of about 40 kilometers lies very nearly at the top of the well-known ozone region. This is the layer from which the very low frequencies or long radio waves of 15 kilocycles and up are reflected. Such low frequencies were almost exclusively used in the early days of transoceanic communication. Communication conditions at these frequencies are unusually stable but since attenuation increases rapidly with wavelength, high power transmitters are needed to cover great distances.

Fig. 2—Curves relating monthly averages of sunspot numbers and the observed corresponding critical frequencies. The critical frequency is the highest frequency that a particular layer can reflect, when the signal enters the region with vertical incidence



Long Distance Radio Signals

Above the D layer at a height of around 110 kilometers is the well-recognized E layer postulated by an American engineer, A. E. Kennelly, in 1902, and shortly thereafter by the English scientist, Oliver Heaviside; it is for this reason sometimes called the Kennelly-Heaviside layer. Its height is fairly constant day and night and probably does not vary by more than ± 10 kilometers. It is this layer that is responsible for turning back to earth the sky waves of broadcast frequencies from 550 to 1500 kc. It is by means of the E layer that commercial broadcast programs may be heard over distances of several hundred miles.

Due to the direct action of sunlight, the E layer becomes so heavily ionized during the daytime that most broadcast waves over any great distance are completely absorbed. With the recombination of ions after sunset the absorption is rapidly reduced and the familiar rise in the field intensities of broadcast waves during the evening hours is the result.

F-layer Reflection

At about twice the height of the E layer is the F region, which varies in height with the time of the day and the season of the year, but which may be placed at approximately 200 kilometers on the average. It is this F region which reflects the shorter radio waves that pass through the E layer—waves or frequencies of from 1500 to 30,000 kc. Somewhere within this range of frequencies radio communication may be carried on day or night with moderate power over thousands of miles because of the reflection of the sky wave from the F layer region. Since this region was postulated by the British scientist, E. V. Appleton, it is sometimes called the Appleton layer.

This F region actually splits into two layers during the daytime, the F_1 layer and the F_2 layer, the F_1 layer forming below the F_2. Waves travelling by way of the F layers suffer considerable absorption especially in the daytime by twice traversing the E region of ionization.

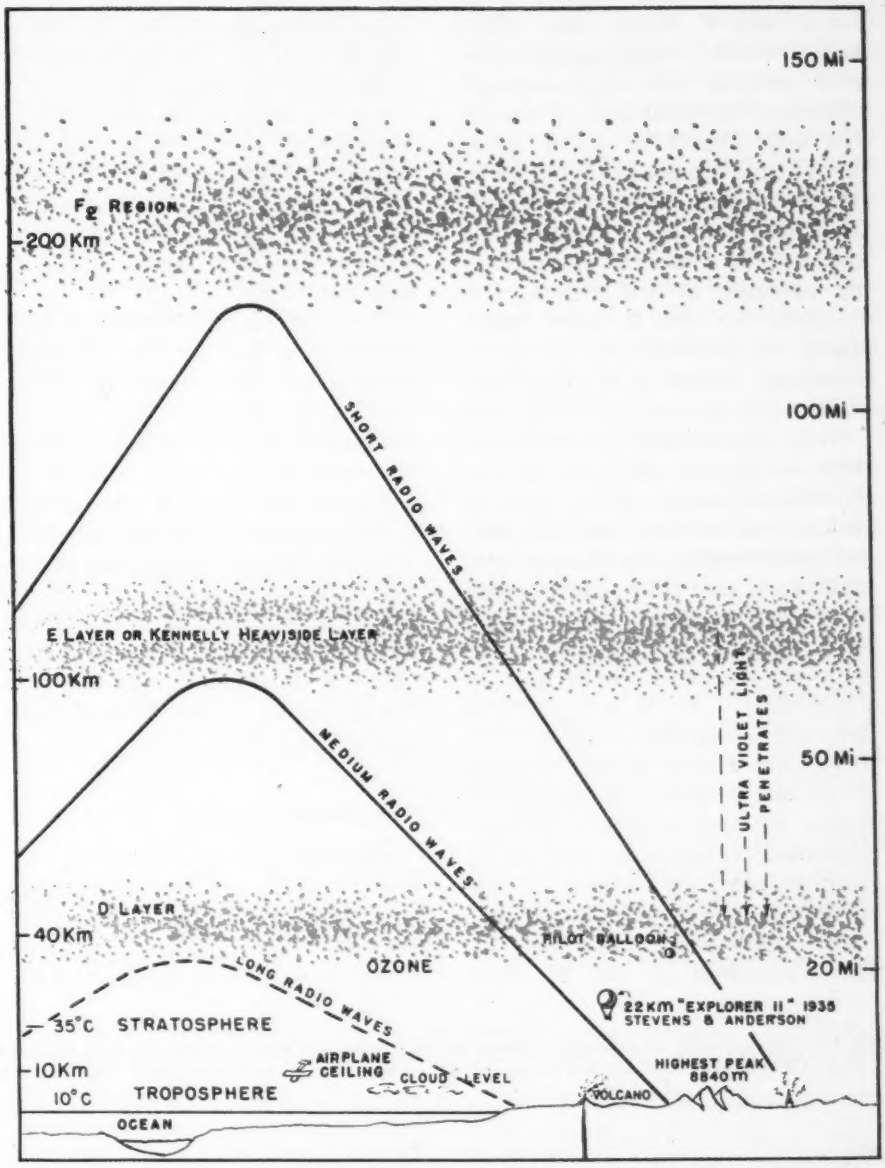


Fig. 1—Cross-section through the earth's atmosphere up to the 150-mile level with a diagram of the heights of ionosphere layers considered in propagation studies

It is generally known that "critical frequency" is a term applied to the highest frequency at which a propagated wave arriving at an ionization layer at normal incidence will be returned to earth. Higher frequencies at normal incidence penetrate the layer and will not be returned. The critical frequencies of the E layer vary widely with the time of day, the season of the year, and with the sun's activity as marked by the numbers of sunspots. A frequency higher than the critical frequency of the E layer will penetrate to the F layer and be returned unless the frequency utilized is above the critical frequency of the F layer at the time.

The short interval elapsed between the time of emission of a given wave at ground level and the time it is received back from the ionized layer at normal incidence may be converted into a "virtual height" of the ionized layer at the time the wave is propagated. The "virtual height" is derived on the assumption that the velocity of the wave is the same as that of light, 3×10^{10} centimeters per sec-

ond. As will be discussed shortly, a critical frequency is indirectly a measure of the ionization for a given layer at the time of observation.

How the critical frequencies in the E and F layers have varied since reliable transmissions have been possible and systematically continued is exhibited in Fig. 2. The upper curve in Fig. 2 shows the sunspot numbers smoothed by twelve months' moving averages from 1934 to 1945 inclusive. The lowest curve shows the corresponding averages of the critical frequencies for the E layer determined at the National Bureau of Standards station at Sterling, near Washington between 9 and 15 A.M.

While the sunspot numbers rose from an average of 16 at the beginning of 1935 to 118 in April of 1937, it will be seen that the critical frequencies of the E layer, designated $f°_E$, rose from approximately 3.06 mc to 3.60 mc and that $f°_E$ fell to a minimum in 1944 of 3.00 mc as the sunspot curve declined to a minimum of 8. It is remarkable that the secondary variations in this twelve-month moving average of sunspot numbers is duplicated almost without exception by corresponding changes in the twelve months' moving average of the curve of E layer critical frequencies.

The middle curve shows the critical frequencies at the F_2 layer represented as $f°_{F_2}$. Again there is a change from 1935 to 1937 in the average critical frequencies from 6.5 mc to nearly 11 mc and a subsequent fall to 5.6 mc corresponding to a minimum in the sunspot curve occurring in 1944. It will be noted that the correspondence of individual variations in the $f°_{F_2}$ curve for some reason does not correspond as closely with the secondary variations in the sunspot curve as do the critical frequencies of the E layer; however, corresponding points can be more or less identified.

It is apparent, for example, that there is a lag of six or seven months in the maximum critical frequencies of the F_2 layer and the maximum of the sunspot curve in the early part of 1937. A small increase in amplitude of the sunspot curve near the end of 1941 is nearly matched by a corresponding rise in the critical frequency of the F_2 curve in December of 1941. There is almost an exact correspondence between the minimum of $f°_{F_2}$ and the minimum of the sunspot curve in the early part of 1944.

Absorption Losses

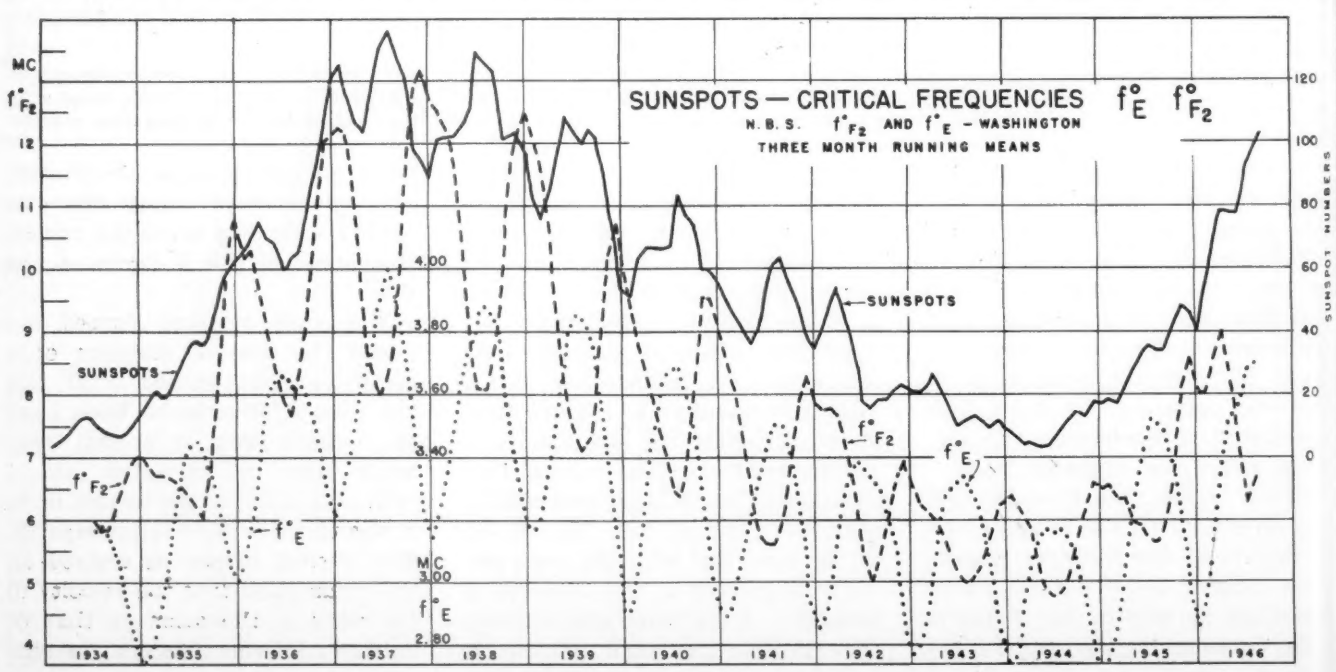
While the critical frequencies embody an important set of data for predicting maximum usable frequencies and optimum workable frequencies for long distance transmission, the actual field intensities observed as an index of performance show that strength of reception depends upon a combination of factors not easily evaluated on the basis of our present state of knowledge of the ionosphere.

Studies at the Cosmic Terrestrial Research Laboratory at Needham, Massachusetts, show in general that for 5 mc reception over the Washington-Needham path the correlation with field intensities received with critical frequencies is far higher for $f°_E$ than for $f°_{F_2}$. Increasing emphasis should be placed upon the importance of the absorption of the transmitted wave in the lower atmosphere as a determining factor in field strength received over a given path for this frequency.

We probably will not be far wrong in picturing the strength of reception of a given wave as depending upon two major factors; (1) How well the wave is reflected from the reflecting layer and (2) how much of the received wave is attenuated by absorption in the lower ionized layers while the wave is passing from the transmitter to the receiver by way of reflection at the reflecting layer.

One may for clarity resort to an optical analogy where the intensity of a reflected beam of light on a thinly silver-backed mirror is meas-

Fig 4—Curves made of seasonal (three month) averages show corresponding changes in critical frequencies in the E and F_2 layers. Graph also reveals the minor or secondary variations in sunspot members measured in three-month moving averages



ured and compared with the intensity of the source. Obviously the brightness of the reflected beam depends both upon (1) the intensity of reflection which is a function, within limits, of the amount of silver deposited on the reflecting surface; and (2) upon the degree of absorption which increases with thickness of the glass in front through which the beam of light passes twice to produce the reflected image.

In this analogy the amount of silver on the back of the mirror is analogous to the number of ions per cubic centimeter in the reflecting layer of the ionosphere; and the thickness of the glass in front of the silvered surface corresponds to the electron density in the lower layers of the ionosphere which the propagated sky wave twice traverses in passing from the transmitter back to the receiver.

The actual change in the electron density at the top of the E layer with the change in sunspots through the decade 1935-1945 is represented in Fig. 3. It will be seen that ionization at the E layer level at the beginning of 1935 was represented by an electron density of 11.5×10^5 electrons per cubic centimeter. While at the peak of solar activity in 1937 electron density at the E layer level was 16.0×10^5 electrons per cubic centimeter. Electron density is the number of electrons N per cubic centimeter of the atmosphere at the maximum ionization level.

The quantity N bears the following relation to the critical frequency f° when the wave is returned to Earth at normal incidence: $N = (f°)^2/81$. The values of electron density used in Fig. 3 were derived from the mean values for each month of the critical frequencies determined at Washington between 9 a.m. and 3 p.m. E.S.T., the curve being smoothed by a twelve months' moving average to eliminate seasonal variations. Again it is remarkable how closely small changes in electron density reflect corresponding changes in solar activity represented by the twelve month moving averages in the sunspot curve.

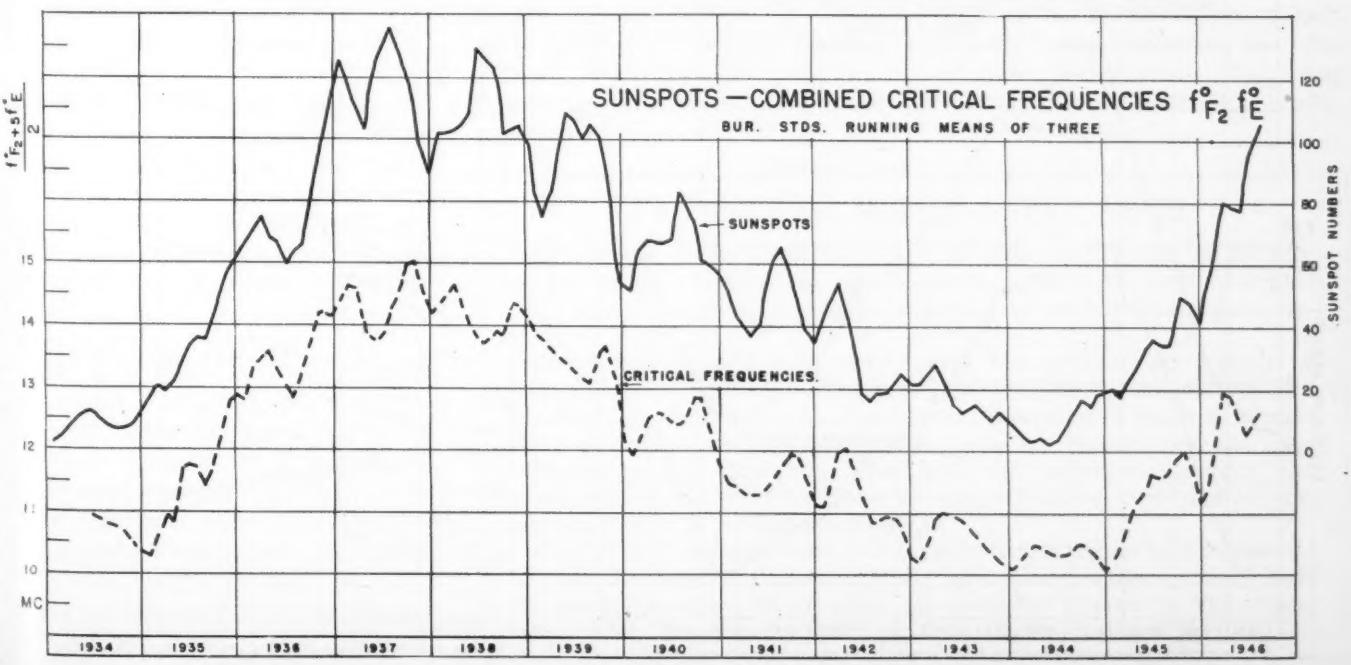
Seasonal Changes

Those familiar with radio wave propagation phenomena are well aware of the marked difference in the seasonal changes in F_2 layer critical frequencies as compared with E layer critical frequencies. The seasonal variation in the critical frequencies at the E and F_2 levels is well shown in Fig. 4. Here it will be noted that ionization is highest at E layer levels in summer and lowest in winter; whereas the critical frequencies at the F_2 layer level indicate maximum values of ionization occur in winter and minimum values in midsummer.

In order to compare these phenomena with sunspot numbers a three months' moving average of the sunspot curve has been plotted at the top of the diagram. The eye catches little correspondence between these three curves except the inverse relationship between the critical frequencies of the E layer and those of the F_2 layer. It should be observed that in this exhibit the scale of frequencies for $f°_E$ is five times that of the scale for critical frequencies $f°_{F_2}$. The scales for the ordinates were so selected that the amplitude of the variations in $f°_E$ and $f°_{F_2}$ should be comparable in the graph, though opposite in phase.

If we now take the mean of the critical frequencies month by month as plotted we obtain a graph representing the expression $f°_K = \frac{f°_{F_2} + 5f°_E}{2}$, where $f°_K$ is used to designate the combination of critical frequencies in the manner indicated. Fig. 5 is the resulting graph. It is to be noted that there is a striking correspondence in the secondary fluctuations as well as in the main trend in the way in which the critical frequencies curve follows the sunspot curve. The greatest departure occurs in 1938, the year following sunspot maximum.

Fig. 5—Plot of combined effect of E and F_2 layers from an empirical relation, compared with corresponding sunspot data. Chart covers sunspot maximum of 1937-38, continuing through the 1944 minimum, and into sunspot activity of September 1946



It should be emphasized that these curves are based on three-month moving averages of corresponding data. The interpretation of these graphs suggests that the integrated ionization in the E and F layers involved in the expression $f°_K$ is more closely dependent on the sunspot number, than would be the case for the critical frequencies of either the E layer or F_2 layer alone.

Anticipating Field Strength

For practical purposes the communication engineer is concerned quite as much with field strengths that may be anticipated for given frequencies over given distances as he is with the prediction of usable frequencies alone. Unfortunately studies of long records of field intensities have shown no simple relation between the anticipated field strength and the state of ionization existing at the reflecting layer. Studies made at the Cosmic Terrestrial Research Laboratory at Needham, Massachusetts, have shown in general that 5 mc reception over the Washington-Needham path shows a more consistent correspondence to critical frequencies of the E layer than of the F layer.

The fact that field strengths diminish more or less regularly with increasing values of $f°_E$ indicates the important part which E layer absorption plays in the attenuation of the received wave. Such relationship as has been found to hold between measured field intensities and $f°_E$, however, vary with the time of day, the season of the year, and with the sunspot cycle.

Attempts to determine a relationship between intensities and critical frequencies of the F_2 layer have been less successful. A plot of field intensities against $f°_{F_2}$ reveals a distorted figure 8, whose pattern varies with the season of the year and probably with the sunspot cycle. A typical example of such a pattern is exhibited in Fig. 6 plotted from data of May, 1945. The figures on the curve represent hourly values of the transmissions of $f°_{F_2}$ at Washington with zero at midnight and 12 corresponding to noon E.S.T.

It will be noted that from 4 a.m. until 7 a.m. critical frequencies advanced for the F_2 layer from 2.6 to 4.8 mc while the measured field intensities of WWV 5 mc received at Needham advanced from log mv 2.1 to 3.2. From 7 hours until 12 noon the critical frequency or $f°_{F_2}$ increased from 4.8 to 5.8 mc. This advance, however, was accompanied by an actual decrease in field intensity from log mv 3.2 to log mv 2.3. This decrease in log mv of the field strength is attributable to the absorption accompanying increased ionization at the E layer level. From 12 noon until 20 hours $f°_{F_2}$ increased from 5.8 to 6.4 with a gain in field intensity from log mv 2.3 to 3.27. During the evening from 20 hours to 24 hours $f°_{F_2}$ fell from 6.4 to 3.8 with a fall in field intensity from log mv 3.27 to log mv 2.32.

The relative simpler relationship between field intensity and critical frequencies of the E layer is shown near the bottom of the graph where the decrease in field intensity from 7 a.m. to 12 noon and the increase from 13 hours to 18 hours exhibits a fairly consistent pattern between field intensities in log mv and decreasing values of $f°_E$.

Monthly Average Data

Another picture of the relationship between field intensities and critical frequencies is to be found in comparing the mean monthly curves of WWV 5 mc received at Needham as compared with the curves of maximum usable frequencies (MUF) and optimum workable frequencies (OWF) calculated for the Washington-Needham path by methods commonly employed and described in the bul-

Fig. 3—Correlation between electron density (values derived from monthly mean values of critical frequencies determined at Washington) and sunspots

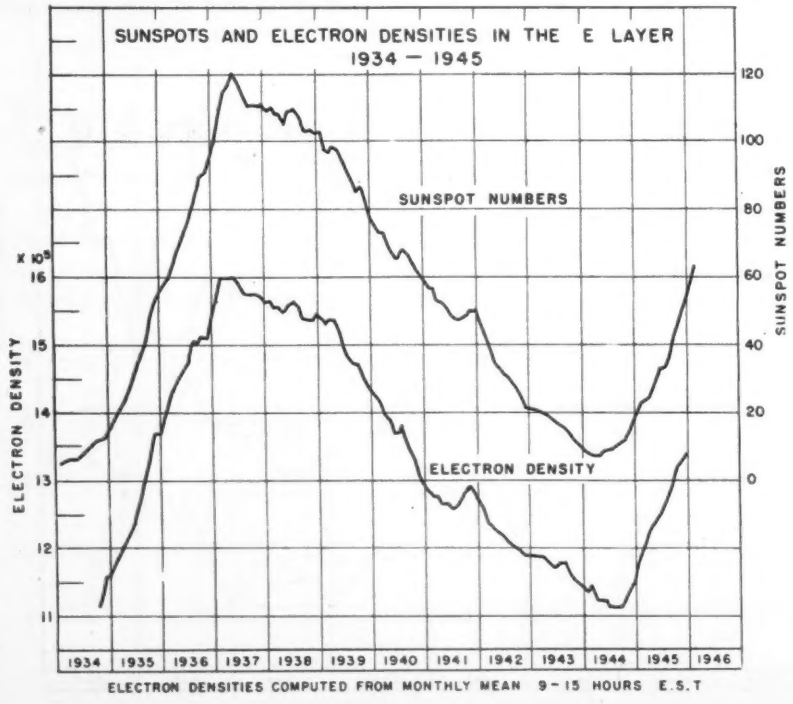
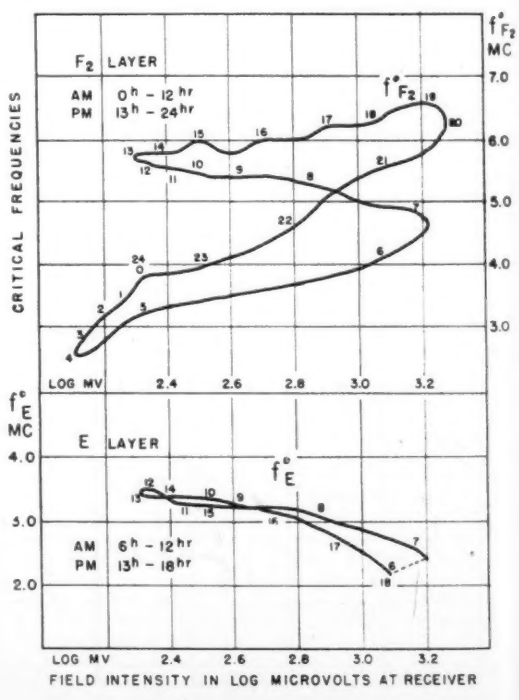
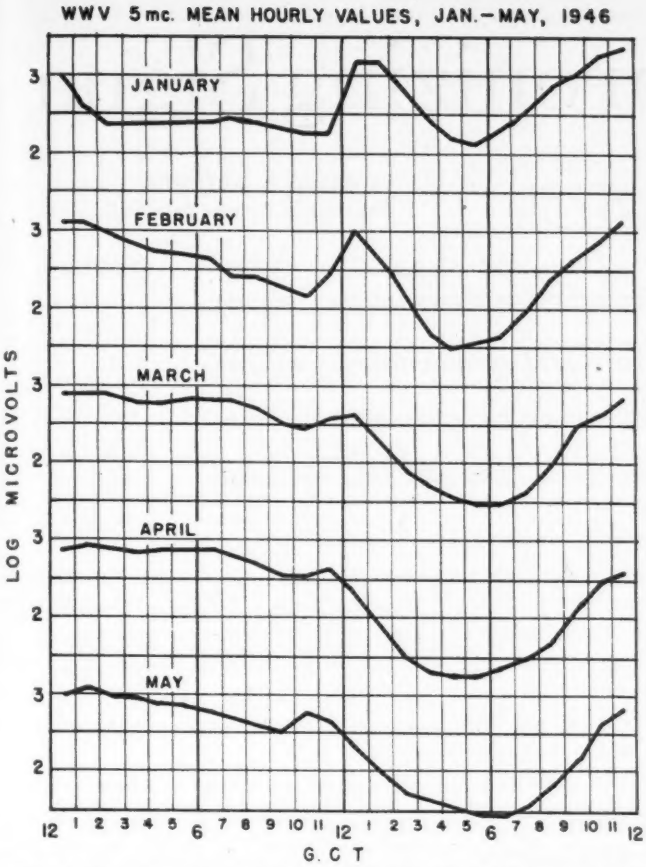


Fig. 6—Another method of plotting intensity and critical frequencies; shows seasonal trends





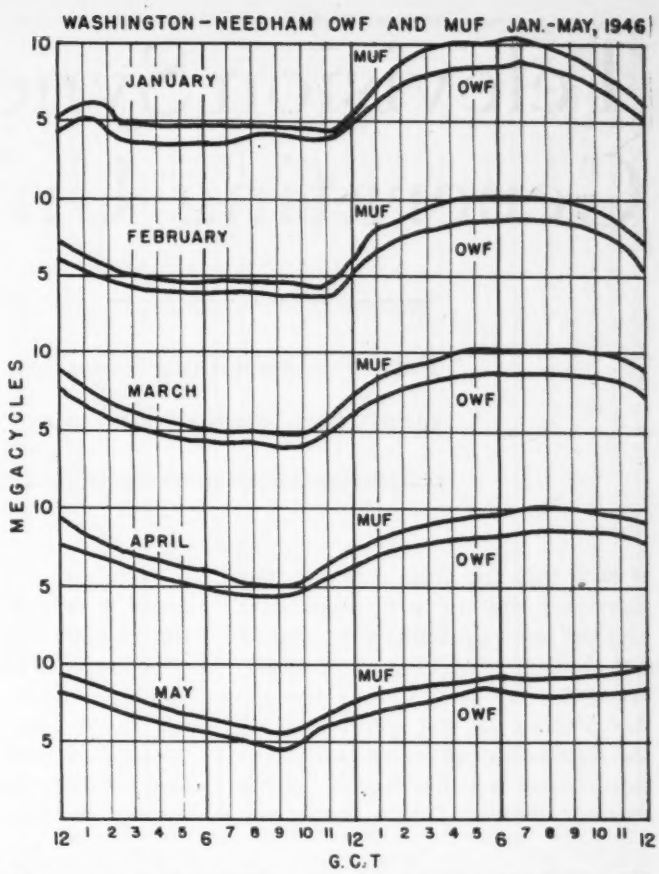


Fig. 7—Mean hourly variations of received field intensity of WWV. Values are plotted for five spring months, revealing level shift.
Fig. 8—The maximum usable and optimum usable frequencies, computed from Needham data, are explained in detail in text

letins of the CRPL of the National Bureau of Standards.

Typical curves for comparison are shown in Figs. 7 and 8, where the mean hourly variation for the field intensity received from WWV 5 mc is plotted from January through May, 1946 in Fig. 7. In Fig. 8 are the corresponding mean curves for maximum usable frequencies (MUF) and the optimum workable frequencies (OWF) for the corresponding months January-May, 1946.

One may regard the comparison of these graphs as a comparison of performance against theoretical predictions based on the usual accepted method for calculating usable frequencies from measured or predicted critical frequencies at the reflecting layer. For example, when a curved Fig. 8 indicates that the OWF at a given hour of a given month is 5 mc, one would anticipate that the corresponding curve of field intensity for 5 mc should show a maximum.

In summary, present predictions of usable frequencies for long-distance communication are dependent upon the value of critical frequencies obtained and predicted from ionospheric data collected at base stations scattered throughout the world. Such critical frequencies for both the F_2 and E layers are shown to bear a close correspondence to the general sunspot trend throughout the eleven-year solar cycle. Some progress has been made in relating critical frequencies to the shorter term variation of sunspots recognized as secondary fluctuations in the main trend of the solar cycle. Records of field intensities for given frequencies over given paths may be regarded as records of actual performance for comparing with prediction.

Present knowledge indicates that the absorption due to transmission through the E layer is an important factor which needs to be taken into account in predicting usable frequencies. The relation between anticipated field strengths and critical frequencies at the reflecting layer is not a simple one. The continuation of the study of field intensity data promises to offer valuable information that may lead to a more satisfactory solution of the problem.

You and This Magazine TELE-TECH

Now in the reader's hands is the first issue of the new TELE-TECH, *combining and expanding the tele-communications technical features of the former Caldwell-Clements magazine, Electronic Industries.*

TELE-TECH, *as you will note, covers the engineering aspects of radio, AM, FM, television and other services, both transmitters and receivers, in their wide applications throughout such fields as broadcasting, commercial communications, aviation, police, railroad, etc., both design and operation. With this new enlarged coverage, the publication is able to render you an intensified and expanded service, not possible with the former magazine.*

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Television Synchronizing Signal Generating Units

By RALPH R. BATCHER,
Consulting Editor, Tele-Tech

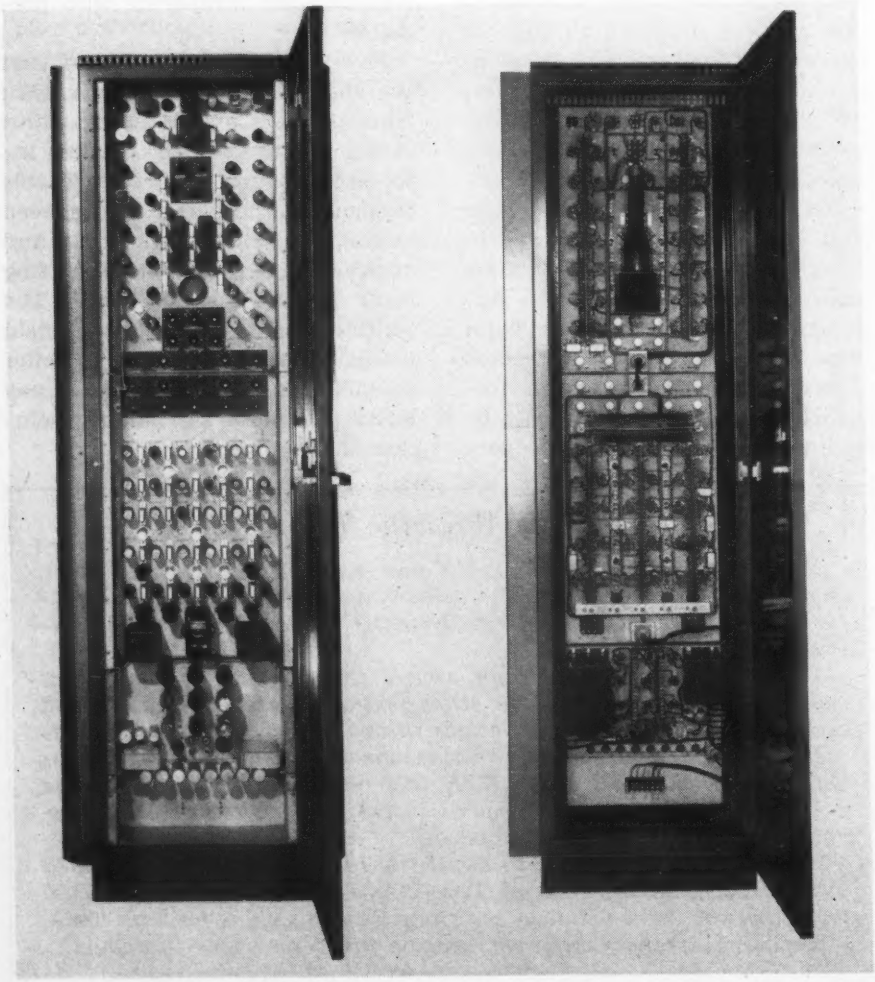
Part 1—Describing television picture and synchronizing equipment for studio, laboratory and receiver production lines

● Now that the basic details of the television system are established and the main problems encountered are those of producing more receivers and more programs on the air, the problem of test equipment for the duplication of regular television signals for routine checks during receiver manufacturing comes up.

Television receiver designers know that one of the characteristics of good design is the effectiveness of the synchronizing signal circuits provided. The 60 cycle and the 15,750 cycle pulses, that are intermingled with the video modulation signals, both have critically-precise waveform, time placement, duration and amplitude. Customer dissatisfaction builds up with the ease with which the receiver slips a frame or otherwise loses sync in the outer areas, when oil-burner, automobile or other interference exists.

In these receivers the sync pulses are sorted out from the highly irregular "mess" of video signals by waveform and amplitude discrimination only. In addition to the gen-

Fig. 1—RCA type TG-1A sync. generator is the "brain center" of television, furnishing timing pulses to the cameras, monitoring oscilloscopes, etc., in a studio, or with a monoscope camera, a complete RMA standard signal, for laboratories and factories



IN the same way that each television broadcaster must set up apparatus to generate standard video control signals, receiver manufacturers are confronted with identical problems. Little useful aid can be given to the production line testing problem by television stations that are on the air. Signals of all types must be generated locally, in a manner identical to that which is used by a television station and having all the accuracy refinements that are required of a television transmitter by FCC rules.

eration of a test pattern which is conveniently done in a Monoscope camera, it is therefore imperative that receiver manufacturers have a source of standard sync signals for circuit design use and for production checking of receivers on the line. Some half dozen manufacturers have produced synchronizing pulse generators, test pattern generators and distribution amplifiers, mainly for television station use, that also serve this purpose. Since

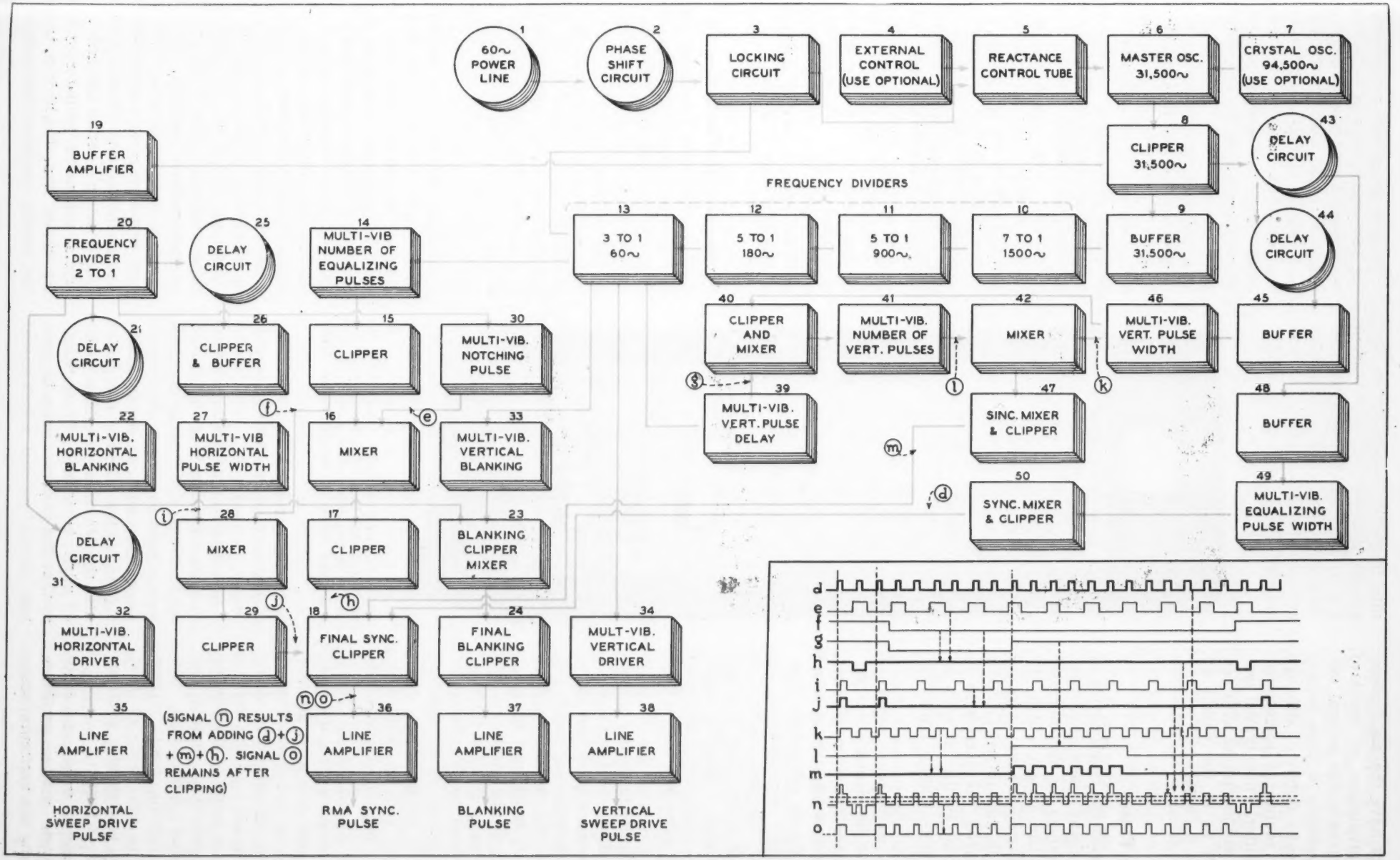


Fig. 4—A television synchronizing generator provides a source of all timing pulses required in a standard RMA, 525 line, 30 frame, interlaced television system, for use at a transmitter or in a laboratory or factory production line test set-up. The RCA type TG-1A generator shown in this block diagram provides horizontal and vertical scanning voltages, the synchronizing signal, video blanking signal, and also (not shown here) circuits to control the sweep frequencies of monitoring oscilloscopes. The timing wave synthesis shown by pulse forms (lower right) are lettered to correspond to waveforms at designated points on the diagram. The time interval between first two vertical (dashed) lines here is the duration of one scanning line. Pulse separation in (d) is 1/31500 second, in (h) 1/60 second. Time axis not to scale. The delay circuits are adjustable to meet local conditions.

both groups have the same objective—the production of standard television signals—the general system arrangements in these designs are not greatly different, although the specific equipment interconnections may differ. Three typical sync generators are illustrated with pertinent data as to the design arrangements for each.

Composite Pulses

In analyzing the requirements of a synchronizing pulse generator, one soon realizes the amazing complexity of the system which the television engineers have set up for themselves in their efforts precisely to superimpose the succession of scenes one on another at each receiver, without unduly complicating circuits.

First, a continuous series of pulses, 15,750 per second, are superimposed on another series of pulses, 60 per second. Neither set of pulses is of the simple off-and-on type. First, in order to extinguish the cathode ray tube spot while it is moving back to the start of a new scanning period, a blanking signal is generated that starts a bit ahead of the sync pulse and lasts a little longer.

An irregularity in timing of even one-tenth microsecond will cause a spot displacement great enough to spoil the reproduction detail. In looking over the methods whereby such accuracy is attained one must pay tribute to the electronic circuit designers "guild" for their efforts in showing how a satisfactory method of control which would be impracticably complex with any other system, can be handled by the simple regularly-known tube circuits.

A lot of tubes are used, of course, but each alone does a simple job: as a buffer, a frequency divider, multivibrator, clipper, mixer or an amplifier. In some of the designs greater use is made of integrating and differentiating circuits for wave shaping applications, and other combinations of pulse mixing arrangements are used, so that each design incorporates a different number of tubes.

In any case, all frequencies come from a single master oscillator source—giving the horizontal scanning frequency of 31,500 cycles. Frequency divider circuit reductions of 7:1, 5:1, 5:1 and 3:1 end up with "ordinary" 60 cycles. The 31,500 cycle source also drives a 2:1 frequency divider to get the 15,750

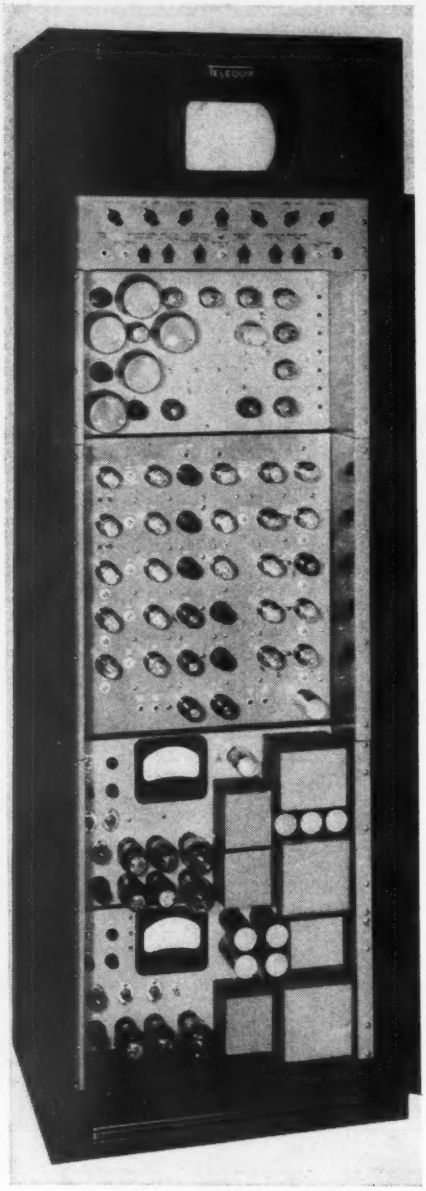


Fig. 2 — Telequip radio type TSG-100 synchronizing generator produces signals with required pulse shapes, durations and intervals for television uses

cycle that gives 525 scanning lines during each of the 30 frames per second.

Here enter other problems: this 60 cycle frequency must be identical to the 60 cycle power line frequency used to operate the receivers, or else unnatural picture shading and other effects take place. Also the television broadcast pickup might be from a remote point, so that the camera must take control.

To show the precise way whereby the succeeding steps in generating the standard sync pulse are carved out, the circuit used in the RCA type TG-1A studio synchronizing system will be analyzed in more detail. Since this equipment meets all requirements of the FCC standards, it may be used either as part of a television transmitter or at a receiver production line. A block diagram is shown in Fig. 4 on page 51. Here a master oscillator (6) is shown feeding a frequency divider string (items 10 to 13) to get the basic control 60 cycles. It is noted that these oscillators both operate at double the scanning frequencies (which are 15,750 lines per second and 30 frames per second). This is done because of the interlacing requirement which requires a 60 field per second rate (two vertical sweeps for each frame) and the requirement that every other vertical sweep start at the middle of a scanning line. These half-line starts require that the fundamental time interval be the duration of one half that of a line.

Power Line Stabilization

Four methods of frequency control for the master oscillator are available by switching. The first position of the switch establishes a free-running condition in the oscillator circuit. The second switch position locks the oscillator to the local 60-cycle power supply (items 1, 2 and 3). The lock-in is maintained by comparing the 60-cycle pulse from the counters with a signal from the 60-cycle power source in a phase detector and discriminator circuit. The dc voltage developed by the discriminator as a result of any phase differences between the 60-cycle pulse and the 60-cycle power source varies the bias on the control grid of the reactance tube item 5, used to control a master oscillator frequency thereby correcting frequency variations (a choice of four time constants being available). The third switch position permits frequency control from an external source, item 4, such as, for example, a remote pickup camera and sync generator. The fourth switch position ties into the crystal controlled oscillator of 94,500 cycles, item 7, which is triple the master oscillator frequency.

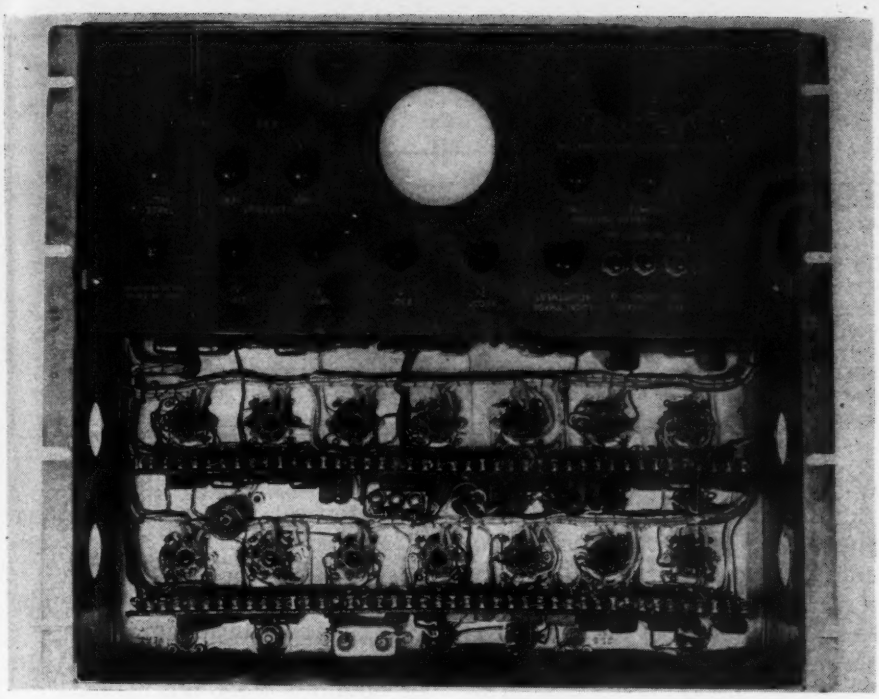


Fig. 3—Front view of Philco sync generator timing unit, with all controls and self-contained monitoring oscillograph. A rear view of this basic unit is shown in Fig. 6

The frequency division circuits (10) to (13) are of the counting circuit design and perform in a similar manner as in Fig. 5. Here the input or driving pulses, applied to the grid of the pentode, are of sufficient amplitude to drive this tube throughout its operating range, from cutoff to saturation. The tube may therefore be considered as a variable resistance ranging from a low value, when the positive portion of the pulse is on the grid, to a very high value when the negative condition exists.

Pulse Counting

Assume that the capacitors (C_1) and (C_2) are completely discharged and that the grid of the pentode is at a maximum positive. The "B" supply voltage is now divided between the low resistance of the tube and its plate load resistor (R_p) causing a minimum voltage E_{p1} to exist at the plate and across (C_3).

When the grid is driven to a value below cutoff the low plate resistance condition is removed and the plate voltage goes to a maximum E_{p2}, causing the second diode to conduct and the capacitors C_3, C_2 and C_1 to charge in series to the new value E_{p2}. Since C_3 already has a charge E_{p1} only the increment E_{p2}-E_{p1} will be added to the three capacitor combination. Since the increment will be divided in inverse proportion to their capacitances only about 1/40 of it will appear across C_1 and C_2 at the cathode of the second diode.

When the grid voltage goes positive again, shunting R_p with the low tube resistance, the plate voltage will return to E_{p1} and the first diode will again conduct discharging C_3 back to the value E_{p1}. Since the second diode will not conduct on the negative swing of the plate voltage, the charge on C_1 and C_2 will remain constant until the plate voltage goes to E_{p2} again when it will receive a fresh charge only slightly smaller than the first. On an oscilloscope with a linear time sweep, the voltage on the cathode of the second diode would appear as a series of stair-steps, each step representing one cycle of the applied voltage.

The cathode of the second section of the diode is connected to the grid of the blocking oscillator through the low impedance winding of the transformer. The bias voltage for the oscillator triode is set so that the front edge of the seventh step of the seventh jump of the counter voltage produces a surge that is sufficient to trigger the blocking oscillator.

During the following positive swing of grid voltage, produced by the oscillator starting action, the grid draws current and discharges C_3. This forces the grid beyond cutoff where it remains until it is again triggered off by the next accumulation of seven pulses.

The combination C_1 and C_2 could be replaced by a single capacitor, but the top on the capacitive voltage divider provides a convenient connection to a monitoring tube that can be switched in to analyze the divider action.

This cathode-ray tube indicator is provided for a quick and accurate check of the frequency division in the counter circuit. The horizontal deflection plates are grounded so the vertical deflection created by the stair-step voltage on the vertical deflection plates creates a series of dots on the screen which corresponds to the number of steps since the cathode ray beam hesitates on each step.

Forming Circuits

It is seen that all basic frequencies needed by the system are derived from this single master oscillator source. They are changed to pulses having the prescribed amplitudes, durations and phases (or arrival times) by the operations of clipper tubes, mixer tubes, delay circuits, multivibrators or straight amplifier tubes used as buffers. Clipper tubes chop off the tops of ac waves of desired frequencies, delivering short or long pulses (with respect to one-half cycle duration) depending on the amplitude at which clipping is made.

These pulses are combined with others in the mixing tubes of stages where they are added (if of the same polarity) or counteract each other as desired. For example, a negative pulse having a duration of 507 units of time (each the period of a cycle of the 31,500 cycle oscillator) combined with continuous series of positive pulses each one unit long, would result in an intermittent transmission of 18 pulses followed by a wait of 507 units of time, then another group of 18 pulses and so on. Delay circuits are provided to retard one pulse with respect to others as required. Multivibrator circuits of the driven type (not free running) are also used to re-form the wave shape as needed. To prevent reaction be-

tween pulse circuits buffer stages are also provided where needed.

Particular applications of such tube combinations will be evident from an analysis of the operation of Fig. 4. For example, the blanking signal (that extinguishes the spot during flyback intervals) is a composite signal consisting of 60-cycle and 15,750-cycle pulses. The 15,750-cycle pulses are generated by the horizontal blanking multivibrator (22), which is synchronized by a negative pulse from the delay line (21). The 60-cycle pulses are generated by the vertical blanking, multibrator (33) which is synchronized by the negative 60-cycle pulse from the pulse former (13). Positive pulses from each multivibrator are applied to the two grids of the blanking clipper and mixer (23), and the mixed signal is fed to the final blanking clipper (24). The sides of the horizontal pulses are steepened by a peaking coil in the plate circuit of (24) and the combined signal is applied to the blanking amplifier 37, a cathode follower form of circuit. The negative blanking signal can also be taken from the plate circuit of this tube through a blocking capacitor should it be needed in the system.

The sweep circuit scanning frequencies for the camera tubes, monitor tubes, etc., also must be provided. The horizontal driving pulses are generated by using pulses from the 15,750-cycle delay line (31) to synchronize the horizontal driving multivibrator (32). A positive pulse from the multivibrator is fed to the grid of the horizontal driving amplifier (35). The amplitude of the pulse is sufficient to bias the tube beyond cut-off thereby clipping off all of the negative portion. A positive pulse is taken from the cathode of the line amplifier and fed to the coaxial connector while a negative pulse is supplied through a coupling capacitor.

Two tubes are required to generate the vertical driving signals. The vertical driving multivibrator (34) is synchronized by the 60-cycle pulse from (13). A positive pulse from the multivibrator drives the vertical driver line amplifier (38). Here again, the driving pulse is of sufficient amplitude to cause the tube to be biased beyond cutoff, thereby removing the negative portion of the pulse. A positive pulse is obtained from the cathode circuit, and a negative pulse from the plate through a blocking capacitor.

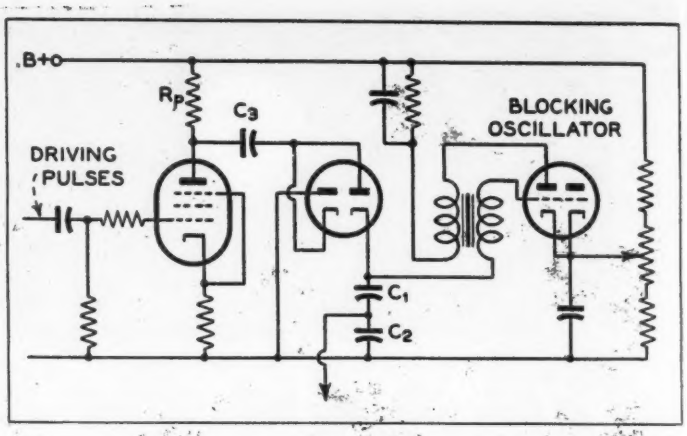


Fig. 5—Typical frequency division circuit (used as items 10 to 13 of Fig. 4) are of the counting variety, giving an output pulse after a specified input pulse count

Pulse Mixing

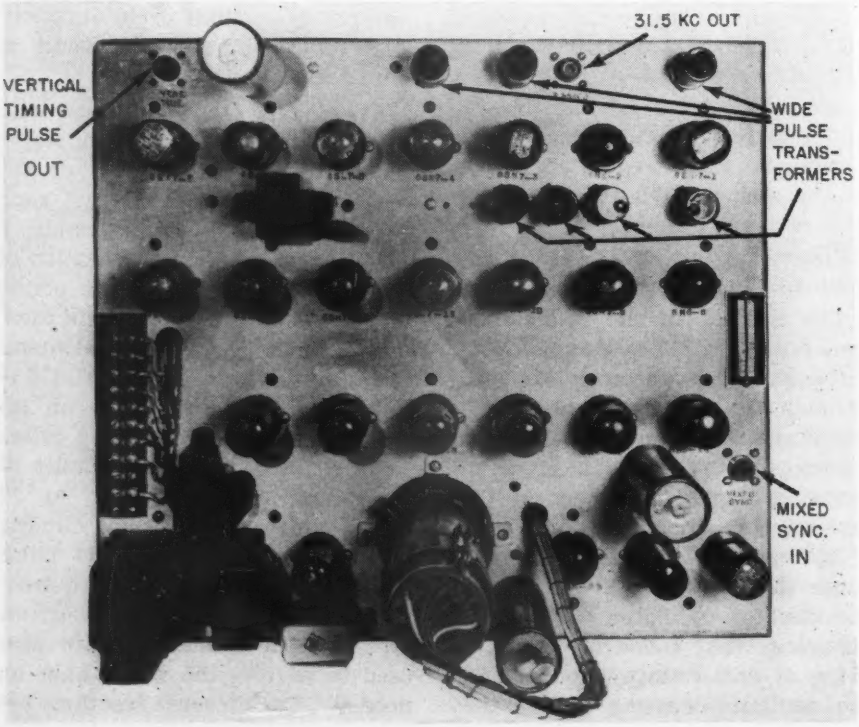
The RMA sync signal has a relatively complicated waveform (Fig. 4) and is developed by mixing ten signals at various stages. The main mixing occurs when four signals, three of which are compositions themselves are applied across the common plate load resistor of clippers (17), (47), (50). At this point the leading edge of the equalizing pulse becomes the leading edge of both the horizontal synchronizing pulse and the vertical synchronizing pulse.

The first of the four signals on the final sync clipper (18) is produced in the equalizing pulse multivibrator (49), which is synchronized by a pulse from the 31,500-cycle delay line (43) through the buffer (48). The positive pulse from the multivibrator is clipped twice in the clipper (50) and fed to the common load resistor the clipper (18).

The second of the signals consists of 15,750-cycle horizontal synchronizing pulses keyed by 60-cycle pulses. The horizontal synchronizing pulses are obtained from the horizontal pulse multivibrator (27) which is synchronized by a pulse from the 15,750-cycle delay line (25) through the buffer (26). A positive pulse from the multivibrator output is applied to the first grid of

(*Continued on page* 140)

Fig. 6—Philco master oscillator section of television synchronizing generator timing unit, delivers 31.5 kc and 60 cycle pulses and tying in with local power frequency



Shorting Gate Noise Suppressor

Locally generated tone of constant amplitude is keyed by signals utilized on an energy basis; these operate a gating circuit

• Completely noise free reception of code signals has been achieved by an ingenious method of utilizing incoming and set noise energy. This excites a local tone generator when the signal being received is absent. When the signal is present its added energy blanks off the local tone generator. The operator thus listens to a locally produced and keyed tone of constant amplitude. As a result no set noise limiting, automatic volume control or beat frequency oscillator is needed.

Even the operation of a spark coil immediately adjacent to the receiver is inaudible when the noise eliminator is used. Invented by Donald L. Hings, vice-president in charge of research for Electronic Laboratories, Inc., Indianapolis, this device has been called a "pulse detector".

As shown in the photograph, the unit is mounted on a separate panel at the top of a standard commercial communications receiver. It includes nine tubes, a pair of slug tuned coils, a filter and other circuit accessories.

Referring to the waveform diagram Fig. 2, the top wave (A) shown is a fading I.C.W. signal. This is limited at its lowest level (marked B-B). The next line (B) shows external impulse noise; (C) set noise; (D) is a combination of external and internal set noise after passing through a limiter of width B-B; (E) shows the result of combining (A) and (D). The additional energy of the signal causes the combined wave to exceed the limit values B-B. The resulting excess voltage produces a short in a low impedance gating circuit which limits the detector circuit. As a result no waveform exists in the detector load circuit during the presence of the CW signal.

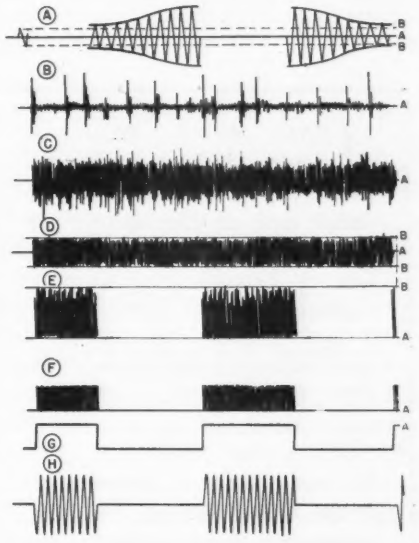


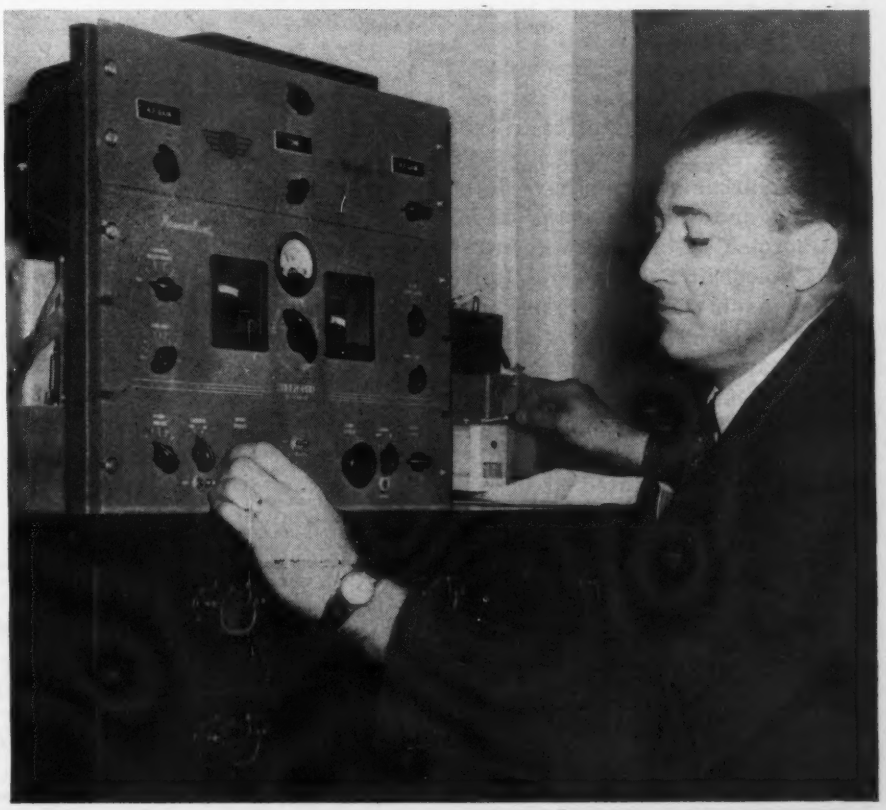
Fig 2—ICW signal and noise waveforms

When no signal is present however, the noise waveform is amplified, limited, rectified and the relatively constant dc component is used as bias to control a balanced amplifier that is being excited by a tone generator. (F) shows the (E) wave after limiting, (G) is the rectified envelope and (H) the local tone signal.

Operating values are generally set on a good receiver so that gating occurs with approximately one microvolt input signal. Anything in excess of this has no detrimental effect. Receiver selectivity, of course, should be the best possible.

Resulting tone is suitable for operating printers and automatic equipment.

Fig. 1—Noise eliminator mounted on receiver, operated by inventor, Donald L. Hings



Status of Broadcasting Overseas

By DR. ARNO HUTH, International Radio Consultant

Present transmitter and receiver situations in nations abroad as affected by war's destruction and rebuilding operations to date

• The war and postwar developments have considerably altered the situation of tele-communications and broadcasting all over the world.

Abroad, during hostilities new and powerful stations were built, mostly for strategic or for information and propaganda purposes. At the same time dozens, hundreds of stations became victims of wartime operations. After the retreat of the German troops, 38 of the 42 French transmitters and 21 of the 46 transmitters in Italy were in ruins, as were the ten Polish stations and countless stations in Soviet Russia. In many countries, transmitters and studios were blasted by their own operators in order to prevent their use by the enemy.

The first and most urgent postwar task, therefore, was the repairing and rebuilding of destroyed stations. Thanks to untiring efforts, remarkable results have been obtained and new networks have been formed within a few months —in France, in Belgium and Italy as well as in Czechoslovakia and Poland. But owing to the shortage of experienced personnel and the lack of material, it will be years before the peacetime level of radio operations can be reestablished in the devastated areas.

Although several countries today have as many or even more transmitters than in the prewar period, their technical facilities are often far from satisfactory. *France,* for example, now has three stations more than in 1939, but the power has been reduced from 2,700,000 to 891,650 watts. The number of transmitters in *Austria* has increased from 9 to 14, but with one exception all are of limited power. *Italy* again has 23 transmitters; the total power, however, does not exceed 409,250, as compared with 1,313,500 watts in 1943. *Belgium* has quickly recovered and even improved its facilities. *Hungary,* on the contrary, which once enjoyed a very adequate network, has no more than two transmitters in Budapest.

ARNO HUTH, Ph.D., is widely known in Europe as an expert on international radio and as the author of outstanding books on the subject of broadcasting abroad, including:

"La Radiodiffusion, Puissance Mondiale" with foreword by Marconi, Paris, 1937
"Radio Today, Broadcasting throughout the World," Geneva, 1942
"Radio—Heute und Morgen," Zurich, 1944

He was a journal contributor of the Berne Bureau, and also communications expert for the U. S. Legation there. In 1946 *Dr. Huth came to America to set up an office as consultant on international radio matters. His address is* 91-17 118*th St., Richmond Hill, N. Y.*

England, Germany

The most striking examples of the contrast between 1939 and 1946 are given by *Great Britain* and *Germany,* the two leading prewar radio countries in Europe. The British Broadcasting Corporation not only succeeded in saving its radio system, but was able even to multiply and strengthen its facilities. The number of British transmitters increased from 23 to 121, and the total power from 1,051,300 to 6,240,000 watts! At present, Great Britain operates some of the most powerful stations in the world, one of them (composed of four transmitters) with 800,000 watts.

The Reichs - Rundfunk - Gesellschaft controlled in 1939 about 50 stations totalling 1,814,000 watts, and it extended its influence with every new country annexed or occupied by Germany. In 1943, no less than 107 long and medium-wave transmitters as well as 23 short-wave transmitters broadcasted Nazi propaganda, day and night.

See Also Large Four-Color Map-Chart Supplement

"World-Wide Tele-Communications Markets"

Sent You With This Issue of TELE-TECH

in fifty-three languages. The collapse of the Reich caused also the collapse of its gigantic radio system, and the destruction of nearly all stations in *Germany*. However, there are again 23 stations within the four occupation zones, and their power exceeds 777,000 watts.

The *Soviet Radio* has experienced important gains and losses during the last years. In 1939, it took over Polish and Baltic stations. Then, with German troops before Moscow and Stalingrad, scores of stations on Russian soil were operated by German engineers and "propaganda companies". Many of these stations subsequently were destroyed, but the Russian authorities already have rebuilt numerous transmitters and established new ones in Moscow, Kiev, Odessa, Stalingrad and Vilna. Today, the Soviet radio voice is certainly stronger than it ever was.

Quite a few new stations have been set up in *China*, but there are still 40 stations less than in prewar times. On the contrary, the number of *Japanese* stations has increased since 1942 from 53 to 114. Their power, however, has been reduced from 570,000 to 397,850 watts, due mainly to the discontinuing of the big Tokyo transmitters. In addition to these stations, operated by the Broadcasting Corporation of Japan, there are 16 others working for the U.S. Army Forces.

Important progress has been achieved in *Latin American* countries which for years were far behind the radio development in North America and Europe. There is not only a marked increase in the number of stations—Mexico had 106 in 1939, and 229 in 1946—but also a notable improvement in their facilities.

U. S. Leads World

However, the leading radio country in the world is, as it has been since the beginning of broadcasting, the United States, with the greatest number of stations offering the finest technical service. And we must not forget that hundreds of U.S. Army and Navy stations, often located in tiny, remote islands, are spreading throughout the five continents news and music from America.

In the same way, the war has upset the situation on the reception side. Millions of sets were lost owing to the destruction of homes, the lack of servicing and, particularly, to the mass confiscation of sets carried out by the Nazi oppressors in occupied European countries. Millions of sets are still out of order, and millions of former radio listeners are unable to get a single program.

Highly characteristic is the example of *Poland*, which, on the eve of the war, had no less than 1,200,000 sets. According to official statistics, the Polish listeners lost 1,099,800 receivers and 1,100,000 receiving antennas, whose total value is estimated at 269,460,000 zlotys. (The currency, in 1939, was $1 = 5.26 zlotys.) In February, 1946, there were in Poland no more than 207,419 licenses, including those for 25,028 loudspeakers connected to 300 relay exchanges. It is, therefore, not surprising that the Polish Government claims from Germany, together with other reparations, the restitution of one million radio sets.

In *Norway* were about 450,000 sets in April, 1940. Nearly all of them were confiscated by the Nazis in autumn, 1941—only 13,000 quislings were officially allowed to listen to the radio. Fortunately enough, a

RADIO RECEIVERS IN USE THROUGHOUT THE WORLD

Latest available data: All totals are 1946 if not otherwise indicated.

Rank[1]	Number of Sets	Country
1	60,000,000	United States
2	10,673,000 (incl. 600,000 ls.†)	Great Britain and Northern Ireland
3	10,551,361, Sept. '40 (incl. 6,110,000 ls.†)	U.S.S.R.
4	5,576,593	France
5	5,500,000 14,000,000 in 1944*	Germany
6	4,500,000 (7,000,000 in 1943) (6,624,326 end 1941)	Japan
7	1,858,614	Sweden
8	1,754,351	Canada
9	1,500,000 (1,859,089 in 1943)	Italy
10	1,479,802 (June, 1945)	Australia
11	1,433,896	Czechoslovakia
12	1,300,000	Argentina
13	1,200,000	Brazil
14	1,009,802	Denmark
15	1,000,000 (1,492,626, Apr., '44, incl. 331,739 ls.)	Netherlands
16	200,000 (904,176, Aug., '44)	Hungary
17	867,365 (incl. 118,095 ls.)	Switzerland
18	820,000	Austria
19	700,000 (1,148,659 in '40)	Belgium
20	600,000	Mexico
21	516,732 (April, 1945)	Finland
22	500,000 (estimates vary between 350,000 and 2,000,000)	China
23	500,000 (1944)	Manchukuo
24	375,453 (March, 1944)	New Zealand
25	375,365 (End 1944)	Spain
26	375,039	South Africa
27	351,728 (Jan., 1944)	Rumania
28	330,000 (429,412, Jan., '41)	Norway
29	250,000	Cuba
30	247,600	Chile
31	207,419 (1,200,000, Aug., '39)	Poland
32	205,130	British India
33	200,000	Colombia
34	177,724	Turkey
35	176,803	Ireland (Eire)
36	175,000	Uruguay
37	150,000 (177,405 end 1940)	Yugoslavia
38	150,000	Venezuela
39	136,186 (End 1944)	Bulgaria
40	133,721	Portugal
41	118,060 (Jan., 1943)	Algeria
42	110,000 (Jan., 1941)	Netherlands E. Indies
43	100,000	Peru
44	86,477 (1941)	Egypt
45	60,000	Puerto Rico
46	58,000	Palestine
47	54,061	French Morocco
48	50,000 (1941)	Hawaii
48-A	50,000	Bolivia
48-B	50,000 (1940)	Philippines
48-C	50,000 (1941)	Thailand
49	39,150 (Jan., 1943)	Tunisia
50	30,000	Luxembourg
50-A	30,000 (1944)	Syria and Lebanon
51	29,843 (1943) (70,000, Oct., '40)	Greece
52	27,339 (End 1944)	Iceland
53	27,000 (1939)	Lybia
54	25,000	Newfoundland
55	24,035 (40,000 end 1943)	Guatemala
56	21,000	Costa Rica
57	20,000	Ecuador
58	15,000	Panama
58-A	15,000	Paraguay
58-B	15,000	Honduras
58-C	15,000	Straits Settlements (Malaya)
59	12,000 (1940)	Hongkong
59-A	12,000	Spanish Morocco
59-B	12,000	Southern Rhodesia
60	10,000	El Salvador
61	8,000	Dominican Republic
62	7,500 (End 1941)	French Indo-China
63	7,000	Nicaragua
64	6,500	Canary Islands
65	6,000	Jamaica
65-A	6,000 (1939)	Ceylon
66	5,160 (1940)	Kenya
67	5,000 (1942)	Mozambique
67-A	5,000 ls.	Malta
68	3,800	Haiti
68-A	3,800 (1942)	Angola
69	3,000	Curacao
69-A	3,000 (1940)	Iran
70	2,000	Bahamas
71	1,500 (1945)	Martinique
72	1,350	British Honduras
73	1,000 (1941)	Afghanistan
74	825 (1945)	Guadeloupe

[1]Based on sets in use.

*The official figure (published by the Reichs-Rundfunk-Gesellschaft) of 16,388,673 licenses included 1,024,507 sets in the "Protectorate Bohemia and Moravia," about 700,000 in Austria, 300,000 in the German-occupied territories of Poland and Russia, as well as the sets in Alsace-Lorraine and Luxembourg.

†ls.—Licenses for wire broadcasting, i.e., loudspeakers connected to relay exchanges.

large number of the stolen sets have been found in Germany and could thus be restituted to their owners; but still in June, 1946, the number of licenses was confined to 330,000, including at least 50,000 battery sets.

Belgium, Holland, and *Italy* also complain about heavy losses of radio sets, as hundreds of thousands were confiscated and destroyed. But the most tragic example is that of *Hungary,* which hoped to reach the million mark by the end of 1944; in October, 1946, only 200,000 sets were still in use.

There was a time when *Germany* possessed the greatest number of radio sets in Europe and drew no less than 360 million marks a year from license fees. In 1944, it had about 14 million sets—the official "propaganda figure" of 16,388,673 included more than 1 million sets in *Bohemia* and *Moravia,* 700,000 in *Austria,* 300,000 in the German-occupied territories of *Poland* and *Russia* as well as all the sets in Alsace-Lorraine and Luxembourg.

It is impossible to say how many sets are still used by German listeners, since no information is given for the Russian Zone. But on the basis of the figures for the American Zone (2,500,000 sets in January, 1946) and those for the French Zone (485,000 in February, 1946), it can be fairly estimated that at least 5 to 5½ million sets are being used in Germany.

On the other hand, several countries have, to a large extent, made up for their wartime losses. The number of licenses in *Great Britain* and *Northern Ireland,* which temporarily declined from 9,132,000 (July, 1940) to 8,836,724 (August, 1944), will reach 11 millions by the beginning of 1947. *France* lost about 200,000 licenses in 1943, but gained 400,000 since that date, and now has about 5,600,000 sets.

(*Continued on page* 144)

NUMBER AND POWER OF BROADCASTING STATIONS

(Late 1946)

NORTH AMERICA

Country	Transmitters	Power (Watts)
Alaska	5	17,250
Bermuda	1	250
Canada	140	534,435
Mexico	229	1,209,860
Newfoundland	7	13,625
St. Pierre and Miquelon	1	500
United States	1100	7,000,000

EUROPE

Country	Transmitters	Power (Watts)
Albania	5	4,300
Andorra	2	80,000
Austria	14	170,850
Azores	2	2,000
Belgium	10	46,200
Bulgaria	4	105,000
Czechoslovakia	19	336,800
Denmark	3	76,000
Eire, see Ireland		
England, see Great Britain		
Finland	19	320,500
France	45	891,650
(prewar:	42	2,700,000)
Germany	23	777,200
(prewar:	50	1,814,000*)
Great Britain and Northern Ireland	121	6,240,000
Greece	3	32,000
Holland, see Netherlands		
Hungary	2	19,000
(1944:	8	157,250)
Iceland	3	108,000
Ireland (Eire)	4	103,500
Italy	23	409,250
(Sept. 1943:	46	1,313,500)
Luxembourg	2	205,000
Monaco	2	10,300
Netherlands	7	375,000
(now operated with reduced power)		
Norway	18	280,400
Poland	13	231,900
Portugal (see also Azores)	13	173,550
Rumania	4	184,000
Russia, see U.S.S.R.		
Spain	75	298,300
Sweden	38	473,375
Switzerland	8	240,300
Turkey	3	160,000
U.S.S.R. (European and Asiatic territories)	130	more than 3,000,000**
Ulster (Northern Ireland), see Great Britain		
United Kingdom, see Great Britain		
Vatican City	3	41,000
Yugoslavia	18	81,300

*In 1943, the German programs were broadcast by 107 long and medium wave transmitters and by 23 short wave transmitters, most of them located in German-occupied countries.

**The power of about 50 Russian transmitters is not officially indicated.

CENTRAL AMERICA

Country	Transmitters	Power (Watts)
Costa Rica	30	60,350
El Salvador	14	7,000
Guatemala	16	25,000
Honduras	4	1,800
British Honduras	1	200
Nicaragua	12	3,130
Panama	13	7,150

WEST INDIES

Country	Transmitters	Power (Watts)
Bahamas	2	5,600
Cuba	99	209,000
Dominican Republic	22	6,425
Guadeloupe	2	400
Haiti	8	3,025
Jamaica	1	200
Leeward Islands	1	250
Martinique	2	5,200
Puerto Rico	7	17,500

ASIA

Country	Transmitters	Power (Watts)
Aden	2	1,000
Afghanistan	1	10,000
Bahrein Islands	1	?
Ceylon	2	11,500
China	58	217,200
(prewar:	100)	
Chosen, see Korea		
Formosa (Taiwan)	7	43,000
Hong Kong	3	9,000
India, British	26	349,850
Indo-China, French	6	15,000
Iran (Persia)	2	16,000
Iraq	2	5,700
Japan	114*	397,850
(1942:	53	570,000)
Korea (Chosen)	15	50,550
Lebanon, see Syria		
Macao	1	500
Malaya, see Straits Settlements		
Manchukuo (Manchuria)	29**	107,600
Netherlands East Indies	28	77,000
(prewar:	68	26,000)
Palestine	3	47,500
Persia, see Iran		
Philippines	3	3,000
(prewar:	10)	
Siam, see Thailand		
Straits Settlements (Malaya)	7	35,000
Syria and Lebanon	3	7,000
Taiwan, see Formosa		
Thailand (Siam)	3	32,500
U.S.S.R., see Europe		

*In addition, there are at present 16 AFRS stations in Japan.

**The three Hsinking stations with 10,000, 20,000, and 100,000 watts are now off the air.

SOUTH AMERICA

Country	Transmitters	Power (Watts)
Argentina	67	600,500
Bolivia	42	10,460
Brazil	126	600,000
Chile	68	233,250
Colombia	114	111,175
Curacao	1	3,000
Ecuador	42	26,600
Guiana, British	1	500
Guiana, Dutch (Surinam)	1	350
Paraguay	10	21,200
Peru	42	41,300
Uruguay	53	162,100
Venezuela	58	111,085

AFRICA

Country	Transmitters	Power (Watts)
Abyssinia, see Ethiopia		
Algeria	7	26,000
Algeria, U. S. Stations	3	150,000
Anglo-Egyptian Sudan	2	1,250
Angola	2	400
Belgian Congo	5	70,400
British Somaliland	1	1,000
Cameroon	2	1,400
Canary Isles	3	9,200
Egypt	6	42,000
Ethiopia (Abyssinia)	1	1,000
French Equatorial Africa (Congo)	3	58,500
French West Africa (Dakar)	2	13,000
French Morocco, see Morocco		
Gold Coast	1	5,000
Guinea, Portuguese	1	250
Kenya	2	3,000
Madagascar	2	1,500
Madeira, Portuguese	1	100
Mauritius	1	500
Morocco, French	3	34,000
Morocco, Spanish	4	2,100
Mozambique	6	11,800
Reunion	3	250
Rhodesia, Northern	2	?
Rhodesia, Southern	8	(Principal transmitter 10,000 W)
Sudan, see Anglo-Egyptian Sudan		
Tangier	1	1,000
Tunisia	2	60,700
Union of South Africa	19	70,000

OCEANIA

Country	Transmitters	Power (Watts)
Australia	139	520,050
Fiji Islands	2	4,400
Hawaii	4	8,000
Hawaii, U. S. Army Station	1	100,000
New Caledonia	3	1,380
New Guinea	3	4,100
New Zealand	23	113,145
Tahiti	1	200

U. S. Radio Statistics, 1947

Radio-electronic output and complete home-set census. Production and use tabulated for industry's past 25 years

THE RADIO-ELECTRONIC INDUSTRY

Data Covers Year Ended December 31, 1946

	Total Investment	Annual Gross Revenue	Number of Employees	Annual Payroll
Radio manufacturers (1100)	$ 60,000,000	$350,000,000	80,000	$ 90,000,000
Radio distributors, dealers, etc.	300,000,000	700,000,000	125,000	200,000,000
Broadcasting stations (1100) including talent costs	100,000,000	380,000,000	*20,000	55,000,000
Commercial communication stations	60,000,000	.....	15,000	8,500,000
Listeners' sets in use (60,000,000)	3,000,000,000	.....	.....	†375,000,000

*Regular staff—not including part-time employes, artists, etc., who number at least 25,000 more.

†Annual operating expense for listeners' sets, for tube replacements, electricity, servicing, etc.

ANNUAL BILL OF U. S. FOR RADIO

Sales of time by broadcasters, 1946	$325,000,000
Talent costs	55,000,000
Electricity, batteries, etc., to operate 60,000,000 receivers	200,000,000
14,000,000 home receivers, at retail value	700,000,000
65,000,000 replacement tubes	82,000,000
Radio parts, supplies, etc.	80,000,000
Phonograph records, 300,000,000	230,000,000
Radio-set repairs, servicing	60,000,000
TOTAL	$1,732,000,000

RADIO SETS IN USE

	January 1, 1947
United States homes with radios	35,000,000
Secondary sets in above homes	15,000,000
Sets in business places, institutions, etc.	4,000,000
Automobile radios	6,000,000
TOTAL sets in United States	60,000,000
Total radio sets in rest of world	65,000,000
TOTAL sets in world	125,000,000

PRODUCTION OF CIVILIAN RADIO EQUIPMENT — 1922 TO 1946

	Total Civilian Sets Manufactured		Total Civilian Tubes Manufactured		Automobile Sets Manufactured		Total Reception Equipment	Auto Sets in Use	Homes with Radio Sets	Total Radio Sets in Use in U. S.	At Close of
	Number	Retail Value	Number	Retail Value	Number	Retail Value	Value	Number	Number	Number	
1922	100,000	$ 5,000,000	1,000,000	$ 6,000,000	.....	.....	$ 60,000,000	.....	260,000	400,000	1922
1923	550,000	30,000,000	4,500,000	12,000,000	.....	.....	151,000,000	.....	1,000,000	1,100,000	1923
1924	1,500,000	100,000,000	12,000,000	36,000,000	.....	.....	358,000,000	.....	2,500,000	3,000,000	1924
1925	2,000,000	165,000,000	20,000,000	48,000,000	.....	.....	430,000,000	.....	3,500,000	4,000,000	1925
1926	1,750,000	200,000,000	30,000,000	58,000,000	.....	.....	506,000,000	.....	5,000,000	5,700,000	1926
1927	1,350,000	168,000,000	41,200,000	67,300,000	.....	.....	425,600,000	.....	6,500,000	7,000,000	1927
1928	3,281,000	400,000,000	50,200,000	110,250,000	.....	.....	690,550,000	.....	7,500,000	8,500,000	1928
1929	4,428,000	600,000,000	69,000,000	172,500,000	.....	.....	842,548,000	.....	9,000,000	10,500,000	1929
1930	3,827,800	300,000,000	52,000,000	119,600,000	34,000	$ 3,000,000	496,432,000	.....	12,048,762	13,000,000	1930
1931	3,420,000	225,000,000	53,000,000	69,550,000	108,000	5,940,000	300,000,000	100,000	14,000,000	15,000,000	1931
1932	3,000,000	140,000,000	44,300,000	48,730,000	143,000	7,150,000	200,000,000	250,000	16,809,562	18,000,000	1932
1933	3,806,000	180,500,000	59,000,000	49,000,000	724,000	28,598,000	300,000,000	500,000	20,402,369	22,000,000	1933
1934	4,084,000	214,500,000	58,000,000	36,600,000	780,000	28,000,000	350,000,000	1,250,000	21,456,000	26,000,000	1934
1935	6,026,800	330,192,480	71,000,000	50,000,000	1,125,000	54,562,500	370,000,000	2,000,000	22,869,000	30,500,000	1935
1936	8,248,000	450,000,000	98,000,000	69,000,000	1,412,000	69,188,000	500,000,000	3,500,000	24,600,000	33,000,000	1936
1937	8,064,780	450,000,000	91,000,000	85,000,000	1,750,000	87,500,000	537,000,000	5,000,000	26,666,500	37,600,000	1937
1938	6,000,000	210,000,000	75,000,000	93,000,000	800,000	32,000,000	350,000,000	6,000,000	28,000,000	40,800,000	1938
1939	10,500,000	354,000,000	91,000,000	114,000,000	1,200,000	48,000,000	375,000,000	6,500,000	28,700,000	45,300,000	1939
1940	11,800,000	450,000,000	115,000,000	115,000,000	1,700,000	60,000,000	584,000,000	7,500,000	29,200,000	51,000,000	1940
1941	13,000,000	460,000,000	130,000,000	143,000,000	2,000,000	70,000,000	610,000,000	8,750,000	29,700,000	56,000,000	1941
1942	4,400,000	154,000,000	87,700,000	94,000,000	350,000	12,250,000	360,000,000	9,000,000	30,800,000	59,340,000	1942
1943	.....	.....	17,000,000	19,000,000	.....	.....	75,000,000	8,000,000	32,000,000	58,000,000	1943
1944	.....	.....	22,000,000	25,000,000	.....	.....	85,000,000	7,000,000	33,000,000	57,000,000	1944
1945	500,000	20,000,000	30,000,000	35,000,000	.....	.....	105,000,000	6,000,000	34,000,000	56,000,000	1945
1946	14,000,000	700,000,000	170,000,000	200,000,000	150,000	9,000,000	825,000,000	6,000,000	35,000,000	60,000,000	1946

Figures for sets give value with tubes in receivers. In normal years, replacement tubes have run 25% to 40% of total tube production. All figures are at retail values. (Statistics Copyrighted by Caldwell-Clements, Inc.)

Identification, Friend or Foe—Radar's Sixth Sense

By LOIS E. STUART,
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Technical details of the Navy's auxiliary system of pulsed transmission and reception for the positive identification of aircraft

• *"A most important factor in war is positive recognition and identification of friend or enemy. Through lack of training, absence of coordination, and due to misunderstandings, friends lose their lives, or the enemy is permitted to escape. It is essential that personnel receive proper indoctrination upon this subject."*

The problem so forcefully emphasized in the foreging quotation imposed a serious limitation on the value of radar in the early days of the war. *RA*dio *D*etection *A*nd *R*anging well may reveal the presence, range, bearing, and elevation of reflective objects—even may reveal to an experienced operator what kind of object has been contacted—but the echo pulses of friendly and hostile craft cannot possibly be told apart.

Despite the success of radar detection with a comparatively primitive set, abreast of the early developmental progress in 1941, we suffered heavy damages in the Battle of Pearl Harbor, because the echoes from attacking Japanese planes were mistaken for those of an expected friendly squadron.

The annals of radar history unhappily are blemished with records of our own guns being turned in fatal error on our own men, because the pulses reflected by friendly craft were believed to denote the approach of the enemy. At one time, Allied pilots even resorted to acrobatics in crude attempts to identify themselves by modulating the radar pulses with their airplanes, but such efforts proved futile more often than not.

Thus, radar lacked a "sixth sense," and the introduction of radar intensified the ancient problem of identification that has confronted every warrior since the Greek siege of Troy. But now another outstanding chapter can be added to the story of radar, because the identification problem was solved before the end of the latest war by a highly specialized application of radar principles known as IFF.

IFF, standing for "Identification, Friend or Foe," is an invaluable auxiliary system of pulse transmission and reception that supplies

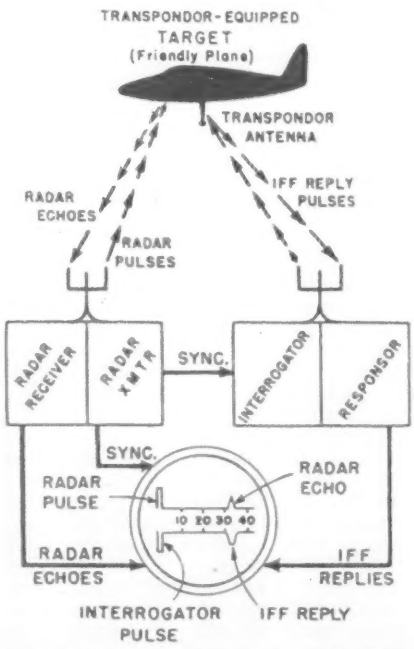


Fig. 1—Basic functions of modern IFF, showing "friendly" reply to a challenge

radar's missing sixth sense. IFF equipment supplements radar detection and location by electronically challenging the unknown radar target for identification, and, conversely, by furnishing automatic identification upon challenge. Although the pulse technique used here is basically similar to conventional radar methods, the challenged friendly target answers automatically with its own characteristic signals instead of merely reflecting the rf echoes. Some of the most complex and elaborate timing circuits in the radar family are required in IFF equipments, but this article is devoted primarily to the system aspects of IFF, because the system must be explained first, and the specific circuits cannot be described—or even fully enumerated—in anything less than a voluminous treatise.

Basic Elements

The first of three basic elements in a modern IFF system is a pulse transmitter, which is located at the radar station and is called an *interrogator*. The interrogator is utilized by the radar operator whenever he picks up a new target, and wishes to challenge it for identification.

The second basic element is a combined pulse receiver and transmitter called a *transpondor*. This is carried by each friendly craft. The transpondor *automatically* transmits an identifying reply pulse whenever it receives a challenge pulse from an interrogator.

The third basic element is called a *responsor*. This equipment is similar to the usual radar receiver and serves to detect the transpondor reply pulses. The responsor always is closely associated with the interrogator, normally in a

single unit called an *interrogator-responsor,* or simply an "I-R." ..

By means of these, the challenging radar operator may determine directly and immediately whether any radar target he challenges is a friend—as indicated by a proper transpondor reply—or a "bogey," presumably a foe—as indicated by the absence of any reply or by the presence of an improper reply.

The transpondor reply pulses may be returned in any one of several codes, some of which can be used for the communication of additional information. These coded replies may be read both visually and aurally at the radar-detection station.

The automatic nature of transpondors is one of their most valuable assets. Nothing more is required to put a transpondor in the fully operative state than to close a power switch and set a selector switch for the prearranged code. Thereafter, the transpondor can be challenged, and will transmit the proper replies, as often as necessary without any attention—or even awareness—on the part of an operator. Shipborne transpondors have remained in continuous service for months at a time with only routine servicing at intervals of 120 hours or more being required to insure their satisfactory performance.

Early IFF Systems

Before probing into some of the numerous complexities of modern IFF, it is well to review the earlier IFF systems. Not only is the story an interesting part of electronic history—hitherto unpublicized because of military restrictions—but the reasons for the circuit intricacies of present IFF equipments cannot be appreciated without some knowledge of the pitfalls IFF has had to overcome.

Quite naturally, the conventional methods of recognition were tried in radar-detection systems, but with little success. The basic means of recognizing ships and aircraft by familiarity with silhouettes and markings, and the display of specially-colored lights, was called into full play, but had an abbreviated application due to fog, darkness, and distance, which hinder the human eye without presenting any barrier to the radar "eye." Recognition of radar-detected targets sometimes was effected by coordinating the radar data with reports from distant observers who actually could see the target. A contributory aid to recognition was the maintenance of a continuous plot of the movements of friendly craft, utilizing radar data, visual observation, and the advance knowledge of tactical plans. But all of these methods require vast, and sometimes unattainable, coordination involving considerable

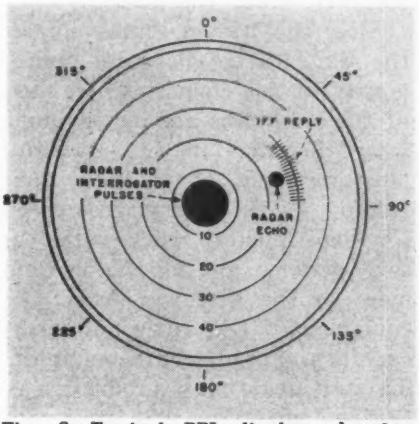


Fig. 2—Typical PPI display showing appearance of IFF reply with relation to interrogation pulse and radar echo

time delay, and time delay cannot be suffered in war! Where airplanes are involved, the conventional methods of recognition are practically worthless, because the speed of approach is so great that identification must be established at the earliest possible moment. The bombs aboard a plane, and the proximity-fused shells in the guns of a surface vessel, make each craft a menace to the other, so that recognition at scores of miles is essential.

To overcome such difficulties by achieving instantaneous and automatic identification, the British devised the first experimental IFF system along with their earliest radars capable of tactical operation. In the earliest attempts at IFF, friendly aircraft and suface vessels each were equipped with an ordinary dipole, which was resonant to the radar frequency, and therefore was capable of reinforcing the echo pulses. This dipole was switched mechanically to produce regular fluctuations in the size of the returning echoes, which then could be recognized as the echoes from a friend.

The beauty of this system lay in its utter simplicity, but simplicity also was its greatest disadvantage. The idea was not inimitable by the enemy, and the simple dipole had a weak and unreliable modulating capability. Furthermore, additional radar frequencies rapidly were being introduced, and the friendly ships and planes had to be equipped with several resonant dipoles. For the comparatively low radar frequencies, the dipole structure was large and bulky; in aircraft this meant excessive parasitic drag and weight. Thus, the system proved to be entirely unworkable, and the British were forced to introduce a radically different identification device.

First Transpondor

In the two subsequent IFF systems, known as Mark 1 and Mark 2, simple parasitic dipole was replaced by a pulse receiver-transmitter—the first transpondor. This equipment was ready for the Battle of Britain in 1940. The transpondor circuits normally remained in the receptive state, but would break into oscillation and "fire" back a powerful pulse upon being energized by the arrival of a radar signal. When transpondor reply pulses and normal echoes were received at the radar station together, an appreciably larger "pip" appeared on the indicator screen, and the detected aircraft or surface vessel was identified as a friend. A "pip" of ordinary size meant an enemy.

The system time lag in the transpondor circuits was brief enough for the reply pulses to overlap the returning echoes instead of appearing separately at slightly greater apparent range on the display.

To accommodate all of the radar frequencies, the transpondor tuning was swept mechanically througout the radar bands then used, and the transpondor antenna was designed to have a broad-band frequency characteristic. Swept tuning was accomplished with a motor-driven variable capacitor. Only one radar band was used in the Mark 1 system, but in the Mark 2 system several different models came into being, each sweeping two or more bands (in three seconds each), for operation

against particular models of radars. The radar-triggered transpondor's role in IFF at present is obsolete, but the development of this equipment must be considered in retrospect as one of the greatest milestones in pulse technique. Only a few years ago it well may have been deemed impossible to design any radio device capable of being triggered by a microwatt-order signal—from a distant transmitter—into emitting a powerful carrier of its own. When this was accomplished, the door was opened to a host of new possibilities in pulse methods and usages for commercial applications, many of which are actualities now, or else are in the advanced stage of experimental progress.

Of supreme importance, however, is the fact that the radar-triggered transpondor gave our flyers and seamen their first reasonable assurance of definite—as well as automatic—identification.

With only slight modification, this type of equipment still performs a valuable service today as a radar beacon, or "racon."

For IFF purposes, the radar-triggered transpondor was called upon to cover an ever-widening range of radio frequencies. As radar development progressed, the new radars invaded higher and higher frequencies of the spectrum, yet the older radars remained in service on the lower frequencies, and a transpondor could not be swept-tuned through them all. Soon it was necessary for every friendly craft to carry several transpondors, covering different frequency bands, and each time a new radar was introduced a new transpondor had to be designed, manufactured on mass-production scale, and then installed. IFF suffered again from many of the same dilemmas that beset the first experimental system.

The I-R is Added

In short, IFF was hamstrung by its dependence on radar frequencies. The only solution presenting itself was a divorce from this dependence—the assignment of a separate and distinct IFF frequency band.

The need for this had been anticipated early by both the British and the United States agencies working on the problem, and plans for such systems had been laid before the beginning of the war. Wartime use of IFF Mark 2 as a separate-band system, with interrogator-responsors servile to search radars, already had been necessary on some naval vessels; finally the I-R was incorporated in the IFF system as a whole. And while the introduction of the interrogator-responsor entailed some display complications, the elimination of multiple - transpondor installations was well worth the price.

After the United States entered the war, IFF development shifted largely to this country where most of the work was conducted under Navy direction in the Hazeltine laboratories at Little Neck, Long Island. To the British goes credit for experimental work with the early systems, and for the development of the first war-tested IFF equipments. Our Navy and Army experts and the Hazeltine engineering staff made mass production of IFF equipments possible, then continued with the development and production of numerous improved models and related testing equipment.

Modern IFF

The functions of the two basic equipments in a modern IFF system are represented graphically in Fig. 1 where a friendly aircraft is reflecting the usual radar pulses while it simultaneously delivers transpondor reply pulses in answer to the challenge pulses of an interrogator-responsor. As the interrogator transmissions are synchronized in perfect time with the radar transmissions—by means of trigger pulses from the radar itself—the IFF replies and the radar echoes appear at equal ranges on a common indicator screen. Had a "PPI" display been used instead of the "A" scope shown in the figure, the echo "pip" and the IFF reply also would have appeared at the same bearing (provided that radar and I-R both use directional antennas).

On "A" scopes, the radar echo is shown as a positive "pip" and the IFF reply as a negative pulse directly beneath the radar echo. Common or separate sweeps may be used, and occasionally the two types of response are displayed on separate indicators. Separate sweeps present the clearest and best displays.

The IFF reply for "PPI" display appears as a crown just beyond the radar echo—when the I-R is equipped with a directional antenna. A separate sweep is not used with the "PPI" type of indicator.

Count-down

The IFF traces are not always repeated at the same rate as the radar traces, due to the use of "count-down" synchronizing methods where the radar pulse-repetition frequency is high. Count-down permits the interrogator to operate with a low duty cycle under all conditions, thereby minimizing the interrogator power drain, reducing the number, weight, and space requirements of the components comprising an I-R unit, and improving the traffic-handling capacity of the system. Typical interrogator transmission rates, therefore, seldom exceed 400 pulses per second. In count-down synchronization, every interrogator transmission is accompanied by a radar transmission, but every radar transmission is not accompanied by an interrogator transmission. For example, the interrogator may send only one pulse for every four radar pulses, or one pulse for every 10 radar pulses, depending on the count-down ratio selected. Most interrogator-responsors contain the necessary frequency-division circuits to count down the master-controlling radar pulses to the desired submultiple, but when frequency-division circuits are not provided in the I-R, this function may be accomplished by an interconnecting equipment between the radar and the I-R. Count down ordinarily does not impair the displayed intensity of the reply pulses, because the transpondor signals usually are stronger than the radar echoes from a given target, and, hence, can be shown clearly at a slower repetition rate.

Either an omni-directional or a directional antenna may be used with an interrogator-responsor, the choice depending wholly on the specialized tactical purpose of the radar with which the I-R is to be used. In any case, the I-R anten-

na is shared by the transmitting and the receiving circuits. Duplexing circuits, similar to those in radars, protect the receiver and prevent interaction. Where a directional antenna is used, it is customary to mount it on the same reflector with the radar array, thus assuring that IFF responses will appear at the same bearing as their corresponding radar echoes.

The transpondor always employs an omni-directional antenna so that its signals can be transmitted instantly to any challenging station within range, regardless of the geographic bearing. Again, a single antenna is shared by the transmitting and receiving circuits.

Power and Sensitivity

The power output from an IFF transmitter is only a small fraction of the power required from a radar transmitter with a comparable service range. This is because a radar must transmit enough power to provide a detectable echo, while the interrogator and the transpondor have no such problem. A radar signal must travel out to the target and back, but an IFF signal—be it a challenge or a reply—needs travel only as far as the target.

When interrogations and replies are made on the same, or nearly the same, radio frequency, careful attention must be given to the relationship between the power output of the transmitters and the sensitivity of the companion receivers. In the case of both transpondors and I-Rs, the receiver must lose sensitivity upon transmission of a pulse by the companion transmitter, and recover it in accordance with a definite "sensitivity law" as time elapses after such transmission. In the case of the transpondor, this is necessary to prevent "transpondor singing," or "ring-around" (transpondors, once triggered, continuing to trigger each other ad infinitum). In the case of the I-R, this is necessary for two reasons: (1) with increase in the power output of the transmitter to give a greater range of operation of the system, action must be taken to prevent the I-R from acting as a radar and obscuring the display with echo pulses of its own; (2) more important yet, the reply signals from a transpondor are much stronger than are the radar pulses echoed from the same distance, and therefore, unless a suitable sensitivity characteristic is used, the I-R has no directivity at the shorter ranges. (With direct interrogation of transpondors by search radars, the "circle of confusion" may have a radius of the order of 15 miles.) This sensitivity characteristic in I-Rs is called "echo suppression," *Sensitivity Time Control* (STC), or *Gain Time Control* (GTC), and its proper treatment in relation to the power output of the equipment is one of the major problems in the design of IFF equipments and systems.

Basic Circuit

It is beyond the purpose of this article to present more than a short summary of the basic circuits in typical interrogator-responsors and transpondors. Briefly, then, an interrogator-responsor is simply a special type of radar. The interrogator circuits begin with a video-pulse oscillator (usually triggered from the co-erating radar), followed by a modulator (power amplifier), and finally by a radio-frequency power oscillator that transmits only upon being modulated. The responsor circuits may be of two general types: superregenerative (usually in airborne equipment only), or superheterodyne. In either case, the functions and sequences of the stage in the main signal channel are the same as the functions and

Fig. 3—Fundamental block diagram of an interrogator-responsor showing location of duplexer at common feed point of antenna

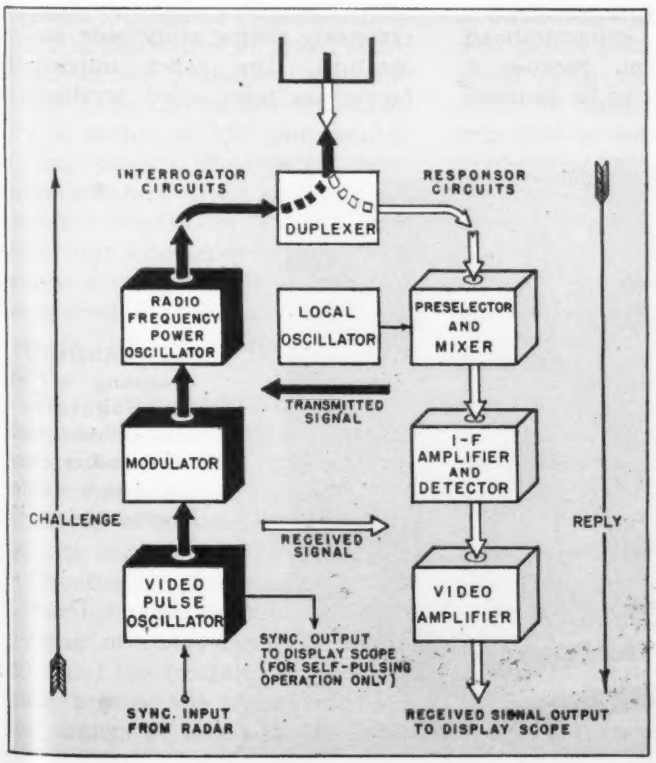
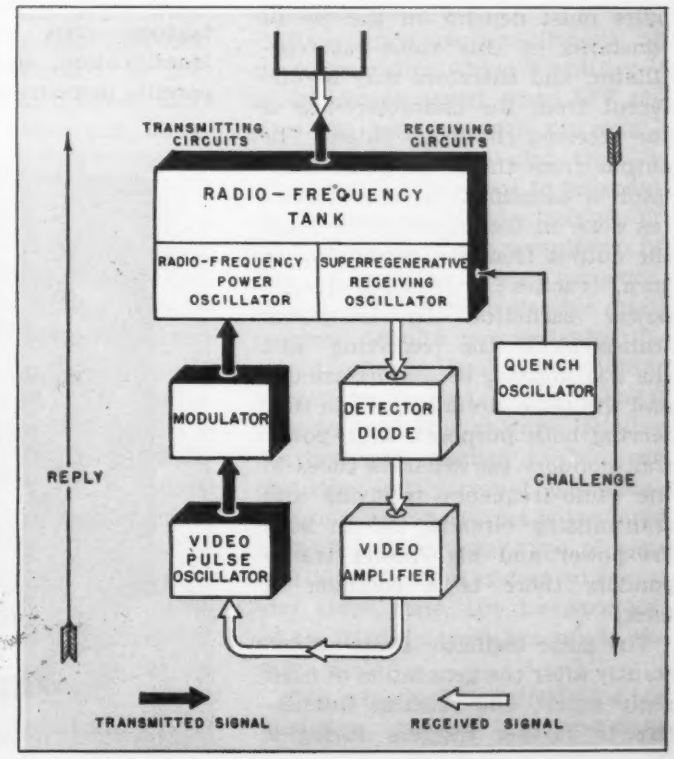


Fig. 4—Basic diagram of transpondor, which differs from a radar in that it is a receiver-transmitter—instead of the reverse



sequences of those in any superregenerative or superheterodyne pulse receiver. The duplexing circuits are located between the interrogator and the responsor at the common feed point to the antenna transmission line. A fundamental block diagram of an interrogator-responsor using a superheterodyne responsor is given in Fig. 3.

A transpondor differs from a radar in one fundamental respect only: a transpondor is a receiver-transmitter instead of a transmitter-receiver. In other words, the receiving circuits energize the transmitting circuits in a transpondor, while the reverse is true of a radar.

Fundamental Transpondor

A fundamental block diagram of a transpondor is shown in Fig. 4. The transpondor circuits form a loop, which is closed by a common receiving and transmitting tank at the antenna entrance and exit point. The received challenge pulse is passed from this tank and a superregenerative receiving oscillator to a detector diode, which demodulates the signal and delivers it to a video amplifier.

Amplified, the demodulated challenge pulse then is used to trigger a video-pulse oscillator, which thereupon initiates the reply pulse. (It is important to remember that the characteristics of the reply pulse must depend on the circuit constants of this video-pulse oscillator, and therefore may be different from the characteristics of the received challenge pulse.) The output from the video-pulse oscillator is amplified in a modulator (as done in the interrogator), and the output from the modulator, in turn, excites a radio-frequency power oscillator. In low-power transpondors the receiving and the transmitting oscillators are one and the same circuits, a single tube serving both purposes. High-power transpondors use separate tubes in the radio-frequency receiving and transmitting circuits, but in both low-power and high-power transpondors there is a common rf tank.

The pulse oscillator shuts off instantly after the generation of each reply signal, and remains insensitive to further triggers during a recovery period of 100 microseconds or more. Thus, the transpondor cannot trigger itself with its own transmitted pulses, and antenna duplexing circuits are not required.

Frequency Sweeping

In a swept-tuned IFF system, the interrogator-responsor operates on a fixed frequency, but transpondor tuning is swept mechanically from the low-frequency end to the high-frequency end of a 30 mc band once every three seconds (approximately). (This includes a short "flyback" interval of one-third second during which the transpondor tuning mechanism resets itself.) The transpondor thus is permitted to be triggered while the tuning mechanism is sweeping the frequencies slightly below, equal to, and slightly above the interrogator-responsor frequency. Of course, this bandwidth factor depends also on the transpondor's receiver sensitivity, the interrogator power, and the distance from the challenging station. In a typical example, an interrogator-responsor (with broadband receiving circuits) will get replies while transpondor tuning is being swept through the frequencies 1.5 mc below and above the I-R mid-frequency—or for about one-fourth second at intervals of slightly less than three seconds.

Frequency sweeping is advantageous even in separate-band identification system, because it permits more traffic to be handled. The maximum number of replies a transpondor can return is limited by the recovery characteristics of its receiver (which is a convenient means for limiting the duty cycle of the radio-frequency power oscillator, when necessary). Since interrogator-responsors at different locations (say, on different ships) cannot always be synchronized with each other, it is possible for an interrogation pulse from one to arrive at a transpondor during one of the "dead" intervals following the reply to an earlier pulse from another I-R. In such a case, there will be no reply to the later pulse.

As the average number of interrogation pulses per second is increased, the average number of replies that fail to be made also increases, until finally a point is reached where one of the I-Rs does not cause a usable reply to be obtained. However, by assigning different frequencies to I-Rs in overlapping service ranges, the swept-tuned transpondor system becomes, in effect, a multiplicity of sub-systems, each having the traffic-handling capacity to which the entire system is limited when all I-R equipments are operated on the same channel.

Coding Methods

The intermittent nature of swept-frequency transpondor replies is one factor that makes an extremely simple reply code easily obtained. The other important factor has been noted previously:

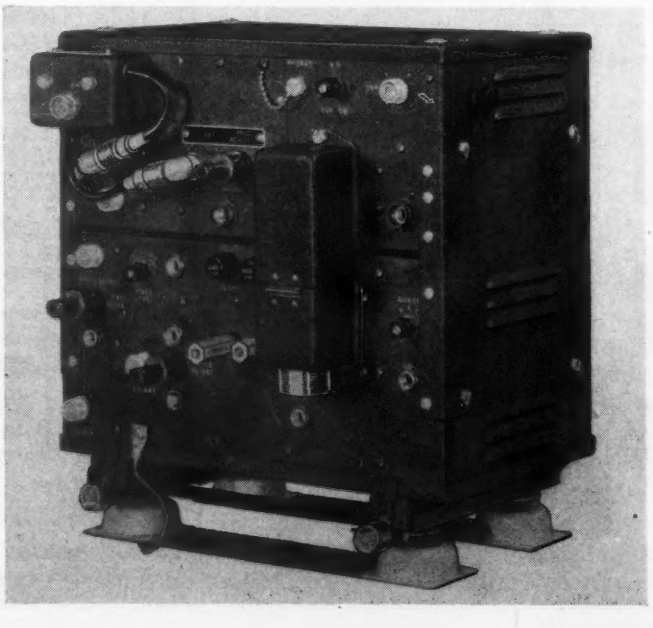


Fig. 5—Aircraft IFF consisting of an interrogator-responsor and two transpondors contained in a single housing; weight 40 lb.

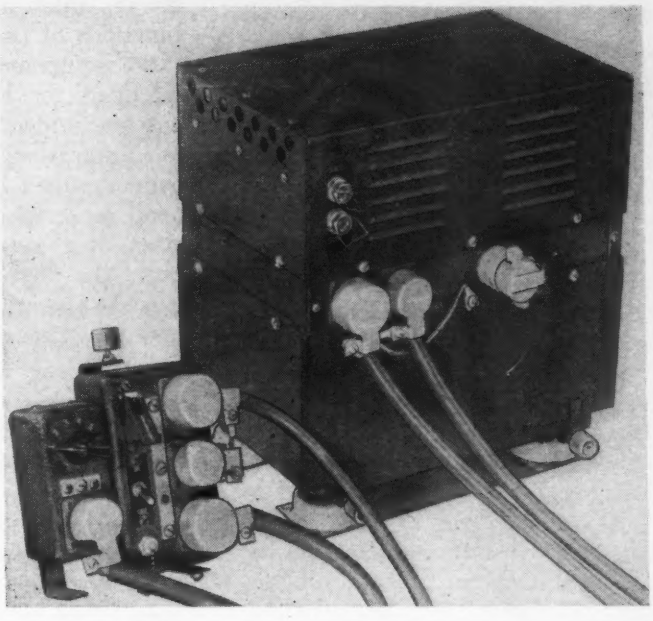


Fig. 6—Shipborne transpondor, originally used in aircraft, but later superseded, delivered 5 watts pulse power and weighs 30 lb.; 10 tubes

the characteristics of the transmitted reply pulses are independent of the characteristics of the received challenge pulses. The challenge pulses serve as triggers only. Once an incoming pulse succeeds in overriding the sensitivity threshold of the transpondor receiver, circuit constants within the transpondor itself determine the characteristics of the transmitted reply pulse. Thus, the characteristics of the reply pulses can be varied between one tuning sweep and another, and selected sequences of such variations can be used for established code purposes. About 12 seconds usually are required to transmit a complete code sequence, and a large number of preset combinations are available; Any one of the codes can be selected easily with a switch on the transpondor control panel. The circuit constants also may be set with a panel-mounted EMERGENCY switch so that only special-type "distress" replies are transmitted. These are recognized at the challenging station as the IFF equivalent of an SOS.

The varying characteristics of all these coded replies appear clearly to an I-R operator on his "A" scope. Audio systems also can be employed to monitor the coded replies by ear.

Directional antennas are not altogether suitable for the challenging of swept-tuned transpondors and the reception of their replies, because the transpondor will not always be tuned to the interrogator-responsor at the instant a directional antenna beam is being rotated past the target. A fairly complex relationship exists between the optimum pulse repetition rate, the rate of frequency sweep, the beam width of the directional antenna, the rate of rotation of this antenna, and the characteristics of the phosphor used in the display, but due to space limitations this relationship cannot be discussed here.

Directional Antennas

Despite the difficulties attendant, antennas having some semblance of directivity (around 22½°) were used on the I-Rs, because they did afford some improvement in the ability to distinguish between targets close to each other, and, more particularly, because they improved the traffic-handling capacity, and reduced the clutter on the display.

In swept-tuned identification systems, however, the reply code can be read with a directional antenna on the I-R only when the antenna is stopped and "search-lighted" on the sector containing a newly detected target long enough for a complete transpondor code sequence. As a complete code sequence requires about 12 seconds, such "sector scanning" involves the danger of losing replies from other targets outside the sector under examination, and omni-directional antennas serving all bearings at once were extensively used.

The IFF responses picked up by an omni-directional antenna appear at random azimuths on a "PPI," though always at the correct range. Often the range data, alone, affords enough information to correlate a transpondor reply to the proper radar echo, but when two, directionally received, radar echoes, and a single, omni-directionally received, transpondor reply appear at equal ranges, the IFF response no longer distinguishes friend from foe. The problem is aggravated when large numbers of intermixed friendly and hostile radar echoes appear at equal ranges.

Fighter Control

Such confusion cannot be tolerated at a Ground Control Interception (GCI) station. The fighter-aircraft director in a GCT station must perform the task of directing his pilots to the enemy with the least possible loss of time, and this requires instantaneous *directional* identification of the friendly fighter planes. While the range and bearing of each craft involved in an interception problem is given by its directionally received radar echo on the "PPI," this very necessary information has little value until the fighter director knows which echoes are being returned by the enemy, which by his own planes, and which are being returned by other friendly craft not under his authority.

There must be no element of doubt regarding these identities—as sometimes occurs when IFF replies are received with an omni-directional antenna—and time is altogether too precious to be spent in scanning the various sectors, or even in awaiting the completion of one transpondor code sequence. Moreover, the fighter director often requires definite personal identification of his individual fighter planes, so that each fighter pilot can be told the enemy's relative bearing with respect to his own position; but personal identification of a specific target is rendered difficult in the usual type of general-identification system where, at any given time, the transpondors of all friendly craft are set to the same code.

Two remedies, both involving the auxiliary use of radiotelephone

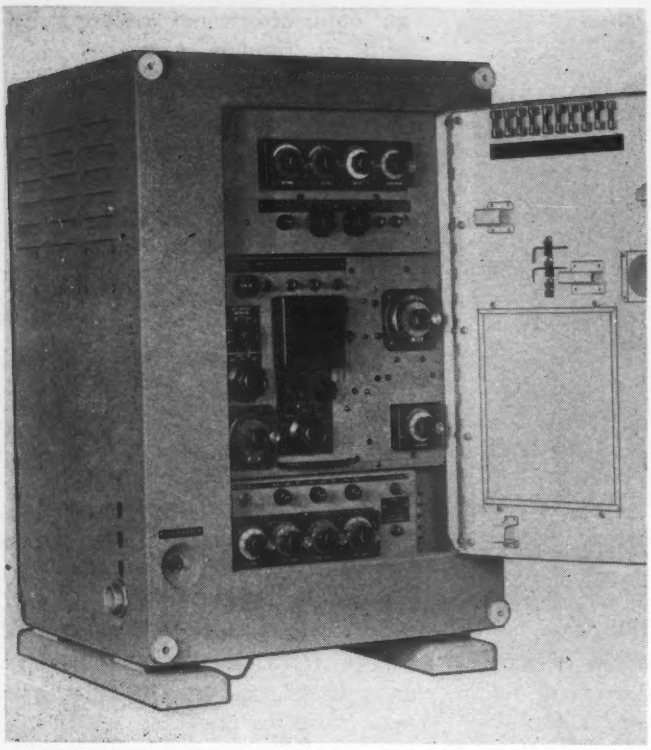


Fig. 7 — Most frequently used shipborne or land based interrogator-responsor, delivers 1500 watts pulse power; has 40 tubes, weighs 472 lb.

communication, were tried successfully to overcome these particular problems.

In one remedy, the target-borne receiver-transmitter was operated on a fixed frequency, neither swept tuning nor reply coding being used. This method of transpondor operation permits the IFF reply to be displayed directionally, because it insures the appearance of an instantaneous answer on the "PPI;" furthermore, no coding cycle has to be awaited. The fixed-tuned transpondors in the friendly fighter planes are not turned on until an interception problem arises whereupon a series of radiotelephone messages are transmitted to as many fighter pilots as necessary, instructing them—one at a time—to return a series of reply signals.

Challenge Response

When and only when, each pilot hears his own command, he presses a switch that enables his fixed-tuned transpondor to reply to the challenging pulses from the GCI station, and these replies appear on the "PPI" at the same range and bearing as the radar echoes from his own airplane. Personal identification is established because only one transpondor replies at a time, and since the enemies' ranges and bearings are given by the radar echoes that have no corresponding IFF replies, it then becomes a simple matter to provide each pilot with the correct vector to follow for a successful interception.

In the other remedy applied to the fighter control problems, the transponder was, again, operated on a fixed frequency, but a modified form of reply coding was retained. In this case the coding cycle was considerably shortened, and the code itself was easily distinguished from the code used for the general-identification purposes. Fighter pilots did not "show their code" until instructed to do so, one at a time, by radiotelephone.

Thus were given two solutions to the long-baffling interception problem, a problem that never could have been solved with conventional radar equipment alone.

Fighter identification is in no wise a substitute for general identification, and the fighter aircraft also must be equipped with transpondor circuits that are capable of making continuous general-identification replies. To effect a saving in weight and space, two transpondors may be contained in the same physical unit, or one transpondor may be made to serve both purposes at effectively the same time. In either case, the dual operation in one physical unit with one antenna is made possible by elaborate time-sharing circuits in the video stages, which are common to both functions of the equipment.

IFF equipments at first were not intended for any purpose except automatic identification and coded communication, nevertheless, transpondors and I-Rs have been called upon to serve as navigational devices ever since their invention. Even the first basic transpondor played—and still plays—its greatest role as a beacon.

Navigational Uses

Sometimes when planes are seeking to find the way back to their base, it is possible to locate and guide them on the basis of their IFF responses at distances from which it is impossible to detect their radar echoes.

A military aircraft on scouting or bombing duty often carries a light-weight interrogator-responsor in addition to its transpondor. Although the airborne I-R is intended primarily for the purpose of recognizing friendly surface vessels, pilots soon discovered that this equipment also may be used to obtain a constant check on their distances from the other friendly planes of their own group. Interrogators are capable of self-pulsing operation, hence do not have to be triggered from a radar during such navigational service periods, and the choice between self-pulsing operation and external triggering is afforded by a handy toggle switch. Therefore, when several planes are flying together in cloud, fog, or darkness, and the possibility of becoming lost or separated is greatest, it is a favorable practice to leave the airborne interrogator-responsor in continuous self-pulsing operation.

By 1945, many airborne I-Rs were equipped with directional antennas, and certain frequencies were set aside for "homing" purposes. Since this use of IFF is on a fixed transpondor frequency, the directional I-R antenna permits a pilot to "home" on another aircraft's transpondor signals, or on the signals from a shipborne or land-based transpondor.

Of the various models of IFF transpondors and interrogator-responsors designed, upward of 300,000 equipments were produced

in the United States. Only a few of these equipments will be described here.

Aircraft IFF equipments are light and compact, like the one shown in Fig. 5 where an interrogator-responsor and two transpondors all are contained in a single housing 16 in. high x 12½ in. wide x 10¾ in. deep. The total weight of this equipment, which has 45 tubes, is only about 40 lb. *including antenna, cabling, and remote-control accessories.* The transpondor receiver sensitivity is 72 decibels below one volt; responsor sensitivity, 86 decibels below one volt. The pulse-power output is necessarily low: about six watts from the transpondor transmitter, and approximately 300 watts from the interrogator. When every circuit is in full operation, the whole set requires only 198 watts input from a 115-volt, or 80-volt, 400-2400-cycle ac source, and 35 watts from a 26-volt dc source.

Shipborne Transpondor

The shipborne transpondor that was most commonly used is shown in Fig. 6. This equipment was designed for, and originally was used in, aircraft where it was superseded by improved equipments during the latter part of the war. The set weighs 30 lbs., has 10 tubes, delivers five watts pulse power, and consumes 105 watts when it is being triggered. Receiver sensitivity is 70-84 decibels below one volt. Overall dimensions are 13 x 9 x 12½ in. Some of these equipments operate from a 12-volt dc source, others from a 24-volt dc source. Other shipborne transpondor models generally are heavier and occupy more space.

The most frequently used shipborne or land-based interrogator-responsor is shown in Fig. 7. This set delivers approximately 1500 watts pulse power at a total current drain of 3.6 amperes from a 115-volt, single-phase, ac source. Receiver sensitivity is 93 decibels below one volt. The set weighs 472 lbs., and has a tube complement of 40. The complete equipment is 30¾ in. high x 21¼ in. wide x 20½ in. deep.

IFF development was not confined to the United Nations. During the war, the British captured some German IFF transpondors before the Nazis had gone into large-scale production. The captured equipments disclosed the intended operating characteristics of the system, thus enabling our engineers to design an interrogator-responsor capable of triggering the German transpondors and detecting their reply pulses. Such an I-R, known as the BQ, was completed and put into service, but the Germans never used their IFF system widely, nor trusted it for quite the same purposes as the Allies' IFF, and therefore little use was made of this interrogator-responsor. The BQ appears in Fig. 8. It is outwardly identical to, and contains circuits similar to, a well-known model series of early Allied I-Rs.

The Japanese also designed equipments for an IFF system, but had not reached the production stage on V-J Day.

But while the Nazis and Nipponese gleaned more than a few details about the existence and the design of our IFF equipments, most of this information was kept from enemy hands by the use of destructors containing small explosive charges, which were installed in all of our airborne transpondors and I-Rs. The destructors could be detonated either by an impact switch operated by the deceleration of a crash landing, or by a manual switch operated by the pilot whenever there was a possibility of his plane falling into enemy territory. The destructors did not contain enough explosives to endanger the operating personnel, or damage anything outside the equipment.

Future Outlook

The importance of IFF equipments as a means of distinguishing friend from foe has overshadowed any commercial value that might have been attached to them during the war-torn years just passed, but when it is recalled that IFF equipments have lent themselves readily to navigational purposes—even in the thick of battle—while simultaneously continuing to provide a means of automatic identification, it is justifiably conclusive that any future radar navigation system must utilize the basic principles of the interrogator-responsor and the transpondor.

Recognizing the need for such dual-purpose equipment in postwar navigation systems, Hazeltine began the development of its recently publicized Lanac and DME systems long before the Jap surrender, and is ready now to equip commercial ships and planes with improved versions of interrogator-responsors and transpondors that are adapted to peacetime requirements.

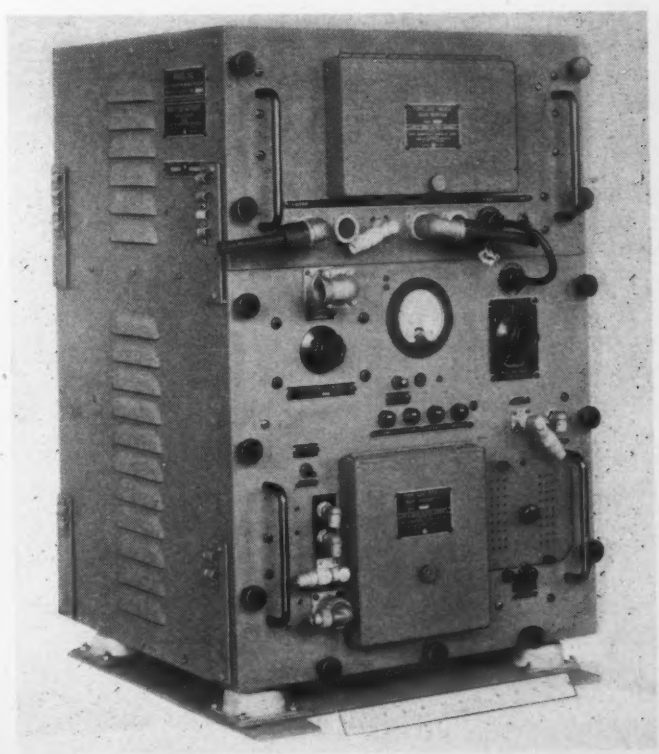


Fig. 8—Late type of I-R developed to trigger German transpondors and detect their reply pulses. Similar to early Allied I-Rs

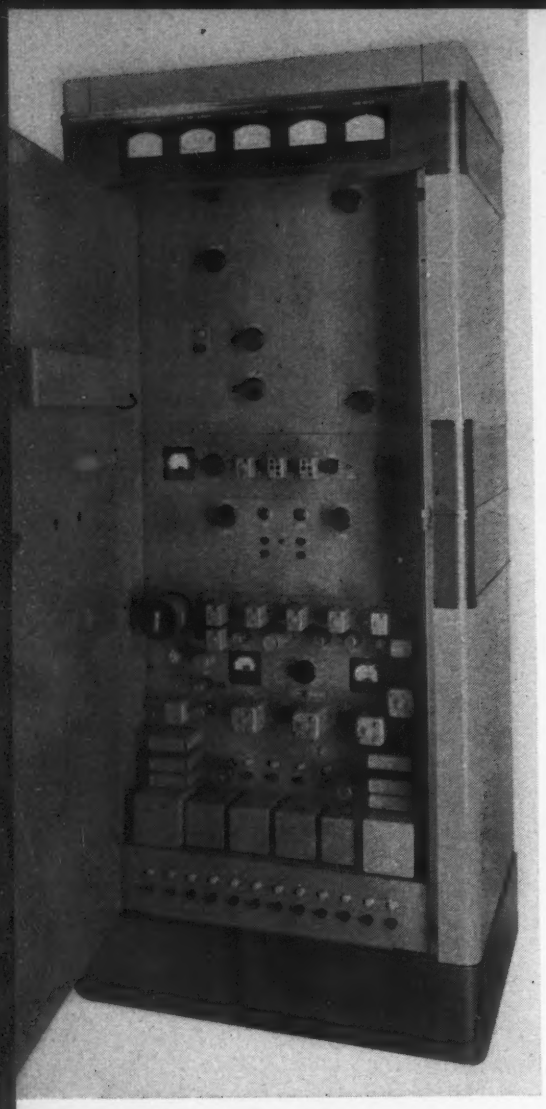


Fig. 1—The transmitter has a basic cubicle size 84 in. high, 30 in. wide and 28 in. deep. At bottom is the high voltage supply, above it low voltage supplies, modulator, relay and control panel, exciter, driver, and at top the final power amplifier. See opposite page

Engineering a 250

By LEO C. KILLIAN and FRED HILTON
Raytheon Mfg. Co., Chicago, Ill.

Design considerations that must be met in the production of equipment to operate efficiently in the 88-108 mc band

• In the former 42-50 mc FM band, tubes available allowed the use of lumped circuit constants. It was only when high powers were required that it became necessary to use linear circuit elements in the tank circuits. Lumped circuits at the present FM frequencies effectively become capacitances. However, linear tuning elements at these frequencies provide for higher Q, greater stability and increased tank efficiency.

The rf circuits are arranged on three separate panels or chassis as shown in Fig. 1 and the block diagram, Fig. 2.

The modulator is a newly developed unit for supplying excitation to the transmitter. This frequency modulator is known as the Cascade Phase Shifter.

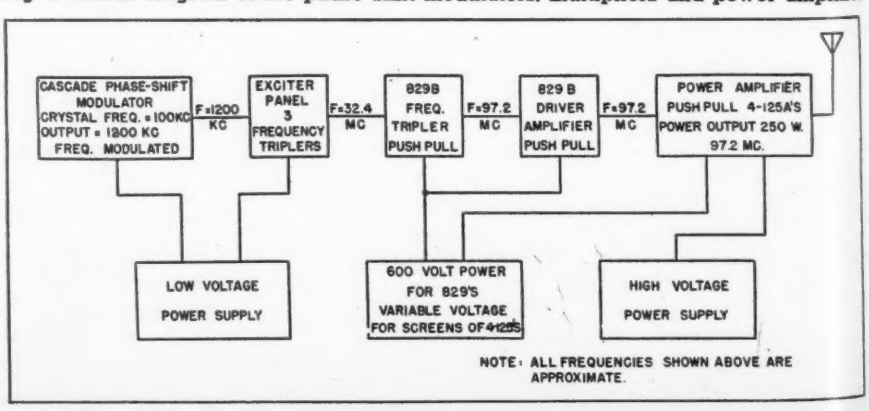
In common with other phase shift modulators, this one also has the advantage of direct crystal control. This feature not only affords the utmost reliability in maintaining the assigned center frequency, but eliminates the need of complicated circuits for automatic frequency control. Unlike other phase shift modulators, this modulator uses more than one phase shift stage to increase the total phase shift that may be obtained at crystal frequency. This enables the frequency multiplication factor to be low enough to avoid the use of heterodyne frequency converters and also helps to improve the FM signal-to-noise ratio.

Basically the Cascade Phase Shift system consists of a crystal oscillator operating at about 100 kc whose rf voltage is phase modulated by a six stage phase shift networks cascaded for rf voltages but the audio voltages controlling them are in parallel. Thus the phase shift produced by each section is additive so that approximately six times the phase shift of a single section is obtained without multiplication of the carrier frequency. The output of the last phase shift section is then amplified and multiplied by a factor of 12 within the modulator unit. (The overall multiplication is 972 from crystal frequency to carrier frequency.)

Phase Shift Network

The basic constant impedance phase shift network is shown in Fig. 4. When X_L is made equal to $2X_C$ any variation in R_2 will have no effect upon the magnitude of the impedance across terminals 1 and 2. The phase of the output voltage will shift, however, between the limits of plus 90° and minus 90° as R_2 is either open circuited or short circuited. With R_2 open, current will flow only through X_L and must be inductive with the voltage leading the current by 90°. With R_2 short circuited and $X_L = 2X_C$ the current through X_C will be twice that through X_L and the net current will be capacitive with the voltage lagging by 90°. With R_2 at intermediate values the voltage vec-

Fig. 2—Block diagram of the phase shift modulators, multipliers and power amplifier


CASCADE PHASE-SHIFT MODULATOR CRYSTAL FREQ. = 100KC OUTPUT = 1200 KC FREQ. MODULATED
F=1200 KC
EXCITER PANEL 3 FREQUENCY TRIPLERS
F=32.4 MC
829B FREQ. TRIPLER PUSH PULL
F=97.2 MC
829 B DRIVER AMPLIFIER PUSH PULL
F=97.2 MC
POWER AMPLIFIER PUSH PULL 4-125A'S POWER OUTPUT 250 W. 97.2 MC.
LOW VOLTAGE POWER SUPPLY
600 VOLT POWER FOR 829'S VARIABLE VOLTAGE FOR SCREENS OF 4-125S
HIGH VOLTAGE POWER SUPPLY
NOTE: ALL FREQUENCIES SHOWN ABOVE ARE APPROXIMATE.

Watt BC Transmitter for FM

tor will be at some intermediate angle. By replacing R_2 with the cathode to ground resistance of a vacuum tube we have a means of controlling the phase shift with audio frequency voltages.

Six stages are required because the largest phase shift obtainable, with low distortion, in any single phase shifter is about 25° or about 13 cycles frequency change for an audio frequency of 30 cycles. To produce the required 75 kc deviation, we multiply 13 by 6, giving 78 cycles shift produced by the six phase shift sections and again multiply by the overall multiplication (972) which follows. This gives ± 75.8 kc deviation. The final multiplication of 972 is obtained through the use of two frequency doublers and five frequency triplers.

Double Tuned Circuits

The frequency doublers and one tripler stage are located on the modulator chassis. The resulting output of the modulator is at 1200 kc. This output is now fed to the exciter chassis.

Early in the design of this transmitter, it was found desirable to use double tuned circuits throughout. These circuits are required in the modulator to provide sufficient bandwidth; elsewhere in the transmitter they are necessary to eliminate unwanted harmonics. This latter case can be easily seen by considering a typical stage such as a frequency tripler. In the plate circuit of the tripler, the third harmonic will be strongest since it is tuned to this harmonic. However, the fundamental, second and fourth harmonics also will appear.

Assuming a fundamental frequency of 1 mc for the stage in question, this means that 1 mc, 2 mc, 3 mc and 4 mc will appear at the plate. Now if all these frequencies are applied to the grid of another frequency tripler stage, the main signal appearing at the plate output will be 9 mc but many other unwanted signals, particularly those at 8 mc and 10 mc will also appear as a result of the fundamental coming through. As can be seen from the foregoing when we have a series of frequency multipliers this condition becomes progressively worse. With double-tuned circuits, however, it is possible to eliminate all but the desired third harmonic signal.

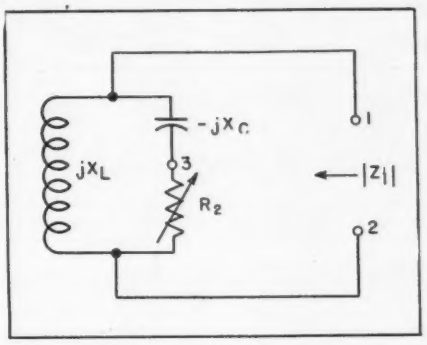


Fig. 4—Basic constant impedance net

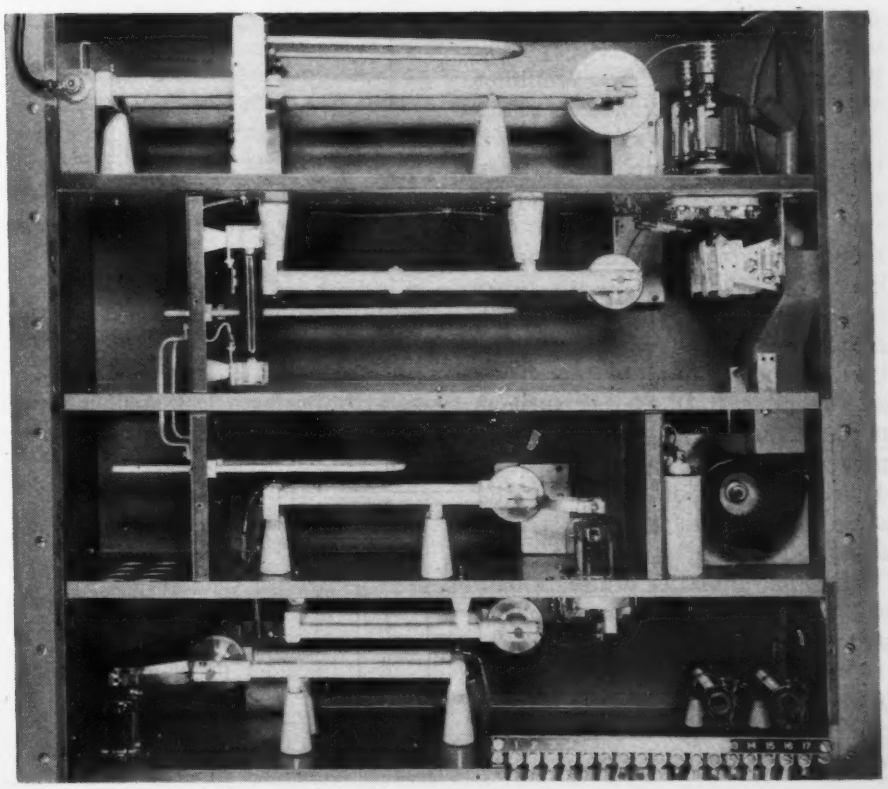
In FM transmitters, interstage shielding is of prime importance. Its use is necessary to reduce unwanted radiation from the frequency multipliers and also to prevent feedback from the final amplifier. Shielding of the final amplifier also reduces radiation losses and raises the efficiency. Elimination of this type of radiation is important to prevent interference with high gain audio equipment which must work in close proximity to the transmitter.

There are three frequency tripler stages in the exciter chassis using two type 6AC7 tubes and one type 6AG7 tube. This gives an overall frequency multiplication of 27 and an output of 32.4 mc. The overall power level is raised to approximately 3 watts in this chassis. Stages on this chassis are tuned by means of a meter which is switched into each grid circuit in turn.

The output of the exciter chassis is link coupled to the grid tank coil of an 829-B push-pull tripler stage. This stage is located with the 829 driver and final power amplifier.

The grid tank of the 829 tripler is the last tuned circuit using lumped circuit constants. The plate circuit of this tripler stage consists of a linear type tank circuit with a two-plate condenser across the

Fig. 3—Capacitance shortened linear transmission line sections and shorting bars



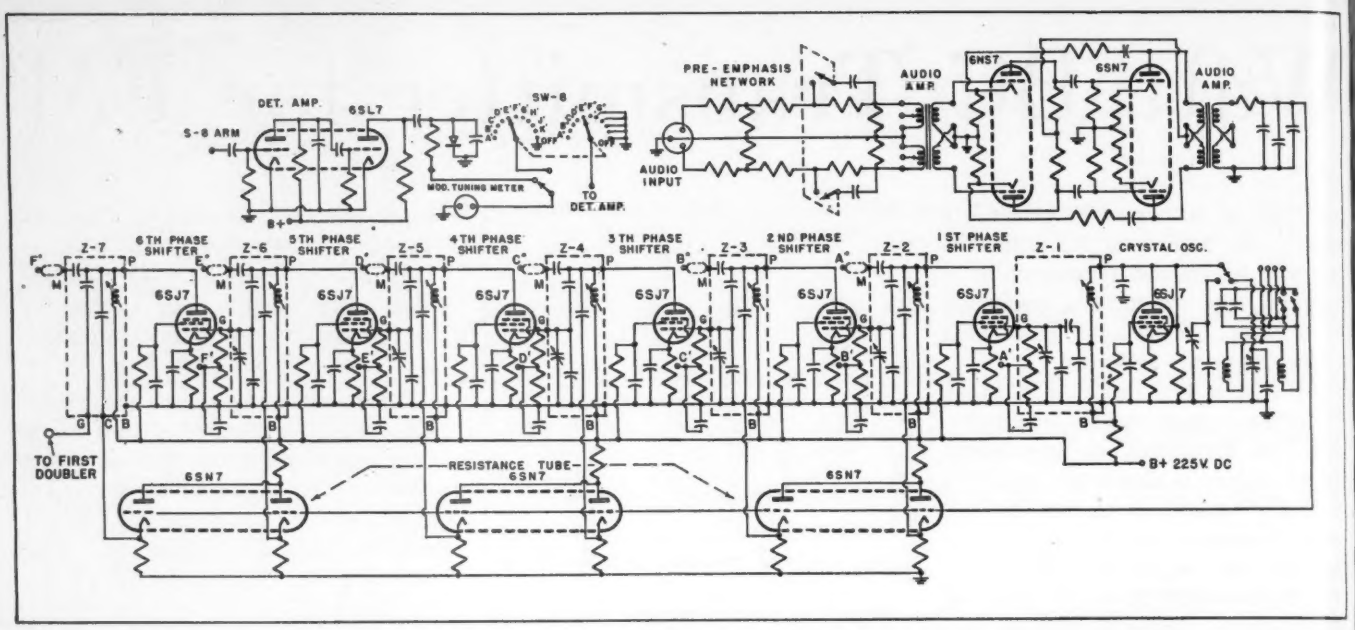


Fig. 5—A portion of the wiring diagram of the Raytheon RF-250 FM transmitter, showing the arrangement of the cascade phase shift system

open end of the frame. The frame spacing yields a calculated characteristic impedance of 250 ohms. Tuning of this circuit is accomplished by means of the condenser which is adjustable from the front panel. A shorting bar provides for a rough frequency setting. Fine tuning is accomplished by use of the condenser and grid meter in the following stage.

Final Tank Tuning

The 829 tripler stage raises the power level to approximately 10 watts and its output is coupled to the input of an 829 driver amplifier. The driver is not a frequency multiplier stage but gives a 50-watt power level to the final amplifier. Both its grid and plate circuits are capacitance shortened transmission line sections having a calculated impedance of 250 ohms. Both tanks have a shorting bar for preliminary frequency adjustment. Neutralization is not required in the driver amplifier. A fixed bias of 50 volts in addition to the grid leak bias prevents parasitic oscillation. The driver amplifier is tuned in the same manner as the 829 tripler stage.

The final amplifier utilizes a pair of Eimac 4-125A tetrodes in a push-pull circuit as shown in Fig. 3.

The amplifier is capable of a power output of 500 watts with the plate voltage used but it is conservatively rated at 250 watts. The power output may be controlled conveniently by means of the voltage applied to the screens of the final amplifier tubes. The curve of Fig. 6 shows this relationship. The plate efficiency is nearly constant over this output power range. In the RF-250 transmitter, a control is provided on the front panel to adjust the screen voltage and hence the output power. Screen grid neutralization is used for this amplifier. This consists of tuning out the screen lead inductance with a series capacitor. This type of neutralization covers a wide band and when once set for a given frequency will hold irrespective of tube variations.

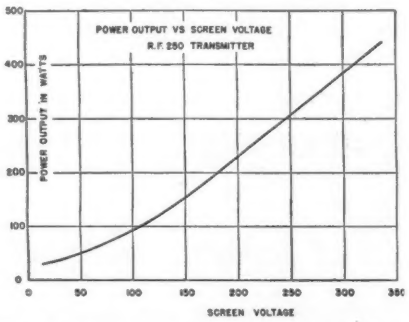
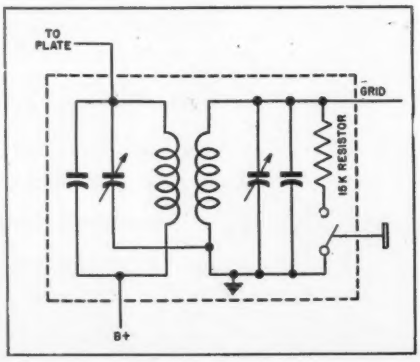


Fig. 6—Power output vs screen voltage

Fig. 7—Circuit of 600 kc rf interstage coil. Depressing pushbutton shunts resistance across the over-coupled secondary coil, decoupling the circuits and permitting the stage to be tuned to a peak by reference to a built-in meter



Since a "dead" front panel is desirable, vertical chassis construction prohibits the use of double ended tube types. In the higher power stages of a transmitter, the tubes are necessarily double ended. This means that vertical chassis construction can be used to advantage only for the low power stages. However, in the higher power stages, the individual components are physically larger so that accessibility is no longer the problem that it was in the low power stages. The main requirement for this case is to allow plenty of room for the components.

FM Field Tests

The range covered by an FM transmitter as a function of the carrier frequency is reported by H. L. Kirke in the B.B.C. (London) Quarterly. The tests indicate that a 90 mc FM signal is less dependable at distances beyond the horizon than a 45 mc FM signal and that it is more affected by the effects of rolling country. Comparison between the two bands shows that a 90 mc station covers only 57% of the area covered by a 45 mc station.

Crystal Control for Stability in VHF Receivers

By NORMAN L. CHALFIN
The Daven Co., Newark, N. J.

Using harmonics of available crystal frequencies, no-drift sets that do not require warm-up can be designed on an inexpensive basis

• A number of circuits using crystals have been developed for use as local oscillator stabilizers for AM pushbutton receiver application. These are grouped in Fig. 1. They are basically Pierce crystal oscillator circuits applied to the 6SA7 tube and its equivalents. Fig. 1a is a straightforward arrangement in which the oscillator section of the mixer tube is operated as a grid-to-plate Pierce crystal oscillator. Fig. 1b illustrates a means whereby the crystals may be switched and a manual tuning unit used. In 1c a variation of the Pierce is shown which permits grounding one side of the crystal, a desirable feature for switching.

Referring to the rf choke in the 6SA7 anode grid in Fig. 1a and the cathode in 1c some explanation is in order: A quartz crystal plate has a tendency to oscillate in two modes of vibration. One of these is determined by its thickness. This is the desired vibration. The frequency will be determined by the thickness in the AT or BT cuts which are commonly used in this service. In untuned circuits a crystal may, under certain conditions, take off on another mode of vibration in which frequency will be determined by its width and length. This will be a much lower frequency than the thickness frequency.

INASMUCH as a crystal controlled local oscillator can be used to provide temperature coefficients as small as two cycles per mc per degree C, such a circuit should prove a formidable competitor for other forms of stabilization. Emphasis is given to this point by the fact that at 100 *mc the frequency change due to copper variation in an unstabilized circuit would amount to* 50 *kc for a* 30°C *temperature change. Even an automatic frequency control circuit with its complications will improve this only by the ratio of* 100 *to* 1.

This tendency is reduced by insertion of a circuit, tuned to a higher frequency than that which would occur due to length and width vibrations, but to a lower frequency than the range in which the crystal oscillator operates on its thickness shear mode of vibration, in the anode or effective anode of the crystal oscillator tube. For general application of broadcast band, ⅜ in. square crystals designed to produce a 455 kc IF, the resonant frequency of the rf trap circuit may be maintained between 400 and 800 kc. For crystals of larger cross section the frequency of the trap may go to a somewhat lower value. The rf end of a typical inexpensive pushbutton radio receiver with crystal controlled local oscillator is illustrated in Fig. 2.

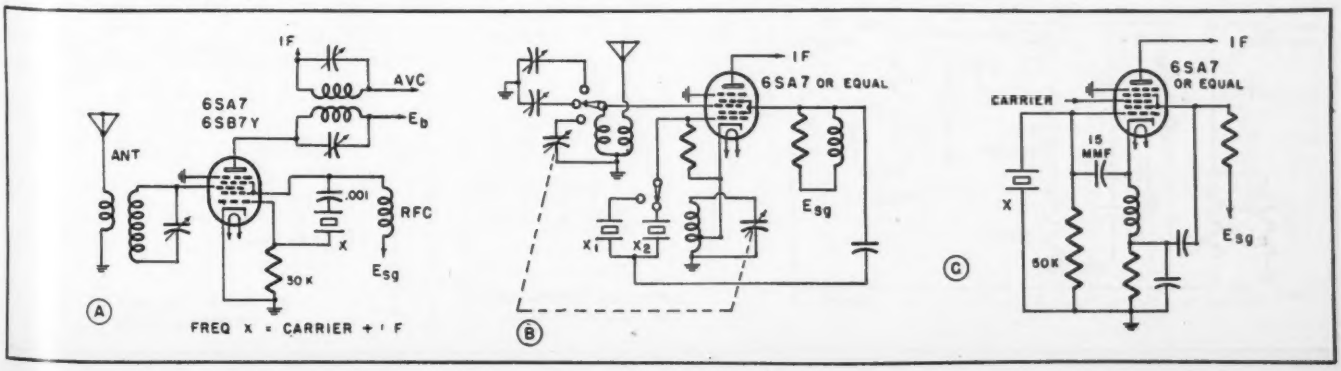
Crystal Harmonics

For FM and television applications harmonics of lower frequency crystals must be used. There are two types of circuits useful for this service:

1—In which the crystal operates on its fundamental frequency and some particular harmonic is emphasized.

2—In which the crystal is a res-

Fig. 1. A—Grid to plate Pierce crystal oscillator; B—Crystal to manual switching circuit; C—Grounded crystal variation of circuit



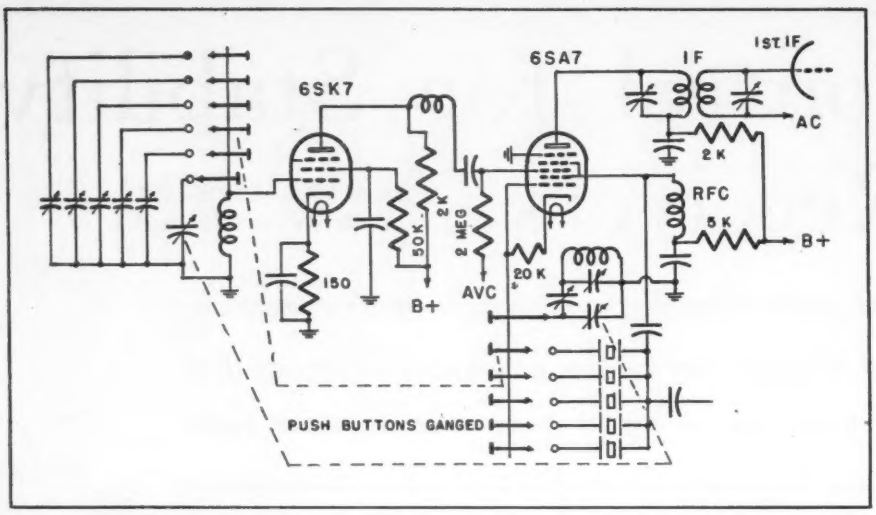


Fig. 2—Circuit for inexpensive pushbutton receiver with crystal controlled oscillator

onant element in a self-excited oscillating circuit operating at an odd harmonic of the nominal crystal frequency.

Considering the oscillators of the first type reference is made to Figs. 3a and 3b. This circuit is a variation of the circuit of Fig. 1c wherein the control grid and screen comprise a "grounded" plate Pierce oscillator with the crystal from control grid to ground and the rf trap circuit in the cathode.

The plate circuit contains a resonant circuit which is tuned to the desired harmonic of the crystal frequency. This arrangement has been used through the fifteenth harmonic with good results with the miniature tube type 6AG5. The unconventional feature of the circuit is the application of positive potential on the suppressor grid. The circuit is currently being operated in experimental FM receivers built by the author with about 125 volts on the suppressor. The effect is somewhat like that of an accelerating anode. There is an increase in the harmonic voltage developed at the desired frequency as the suppressor voltage is made more positive until it equals the screen potential. Beyond this no further increase is obtained.

At the 10th harmonic four to six volts are developed on the mixer grid with crystals in the range 8 to 9 mc. This is more than ample for mixing with a 6AG5 or 6AK5 mixer.

Pushbutton Control

In Fig. 4, a suggested circuit is shown for economical application of pushbutton control to an FM receiver in the 88-108 mc band having an rf stage and an aperiodic mixer input. In this way the rf stage in addition to its amplifying action acts as buffer against radiation of the crystal oscillations from the antenna.

The circuit of Fig. 3a may be used for television receivers if certain precautions are observed. Specifically the crystal frequency or its harmonics may not fall within the IF band for video and audio (in current receivers this would be between 21 and 27 mc) and none may equal the frequencies within the rf pass band, 6 mc wide for any channel. A chart is included which lists frequencies usable for television sets with RMA standard IF's. This table refers to the application of the circuit of Figs. 3a and 3b.

TABLE I

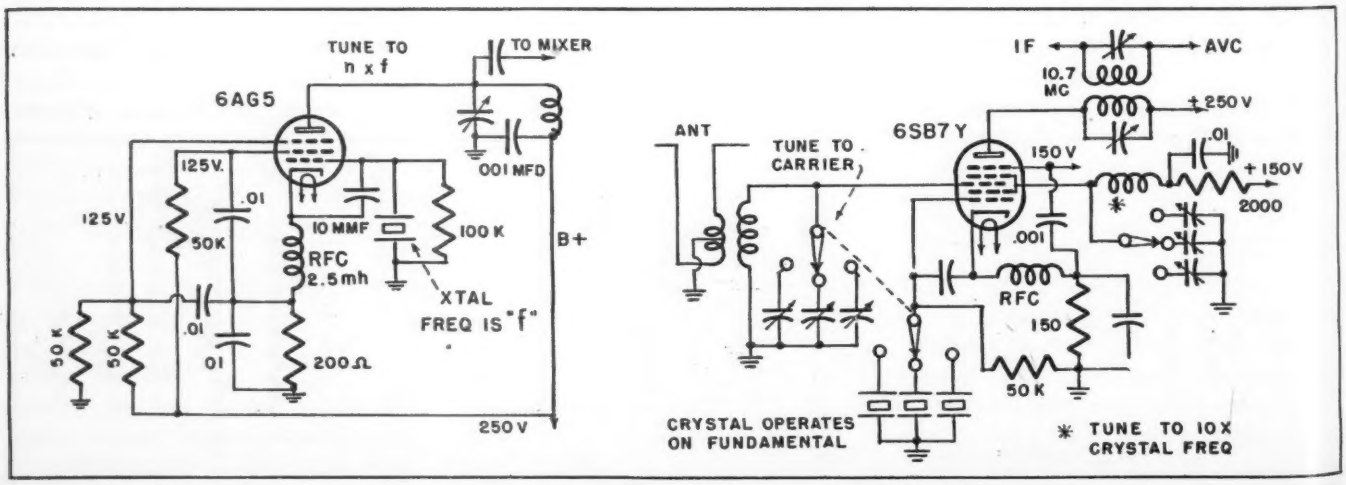
Crystal Frequencies for the 6 Tele Channels Below 100 MC For IF's Video 26.4 and Audio 21.9

Channel	Xtal Freq. (kc)	Harmonic No.	Osc. Freq. (mc)
1	10.235.714	7th	71.65
2	9.072.222	9th	81.65
3	9.738.888	9th	87.65
4	9.365.	10th	93.65
5	9.422.727	11th	103.65
6	9.982.727	11th	109.65

The second type of harmonic oscillator circuit has the crystal in a resonant application. The circuit shown in Fig. 5 is the basic harmonic oscillator. It is drawn so that its bridge-like operation is apparent. The capacitance C_b and the holder capacity of the crystal are balanced as are the sections of the tank coil. When the tank is tuned to resonance with a harmonic of the crystal frequency (the operation is primarily effective only on odd harmonics), the oscillator frequency is locked to the crystal at the harmonic frequency. No fundamental of the crystal is present.

As shown in Fig. 6, the plate circuit may be tuned to any harmonic

Fig. 3—A, B—Grounded crystal scheme with plate circuit tuned up to 15th harmonic. At the 10th harmonic 4 to 6 volts will appear



of the grid tank frequency. As applied by the author the crystal frequencies in use are operating on the fifth harmonic and the plate circuit doubles this frequency.

Crystal frequencies and circuit frequencies for harmonic oscillator operation in television receivers for the six frequencies below 100 mc are given in Table II.

TABLE II

Nominal Channel	Xtal Freq. (kc)	Grid Tank Freq. (mc)	Plate Tank Freq. (mc)
1	7165	35.825	71.65
2	8165	40.825	81.65
3	8765	43.825	87.65
4	9365	46.825	93.65
5	10365	51.825	103.65
6	10965	54.825	109.65

A variation of this harmonic oscillator using the midget tube type 6AK5 can be made. As many as 12 volts at the oscillator frequency have been measured on the grid of the mixer tube with the 6AK5 oscillator at 64 mc for the old television frequencies. At the higher frequencies lower values are to be anticipated.

In any case the final frequency is the 10th harmonic of the nominal crystal frequency. The last described circuits may, too, be applied to FM receivers. Where switching is required, the mechanical problems of the switch must be considered from the standpoint of maintaining minimum lead lengths and distributed capacities.

The ability to turn on a television receiver or an FM receiver without waiting half an hour or more before the circuits stabilize sufficiently not to require retuning will certainly outweigh any small cost differential that crystals, at this writing, would entail in the construction of receivers for the high frequencies. Actually, the cost should work out to less than self-excited oscillators because for crystal control many of the mechanical design factors can be ignored.

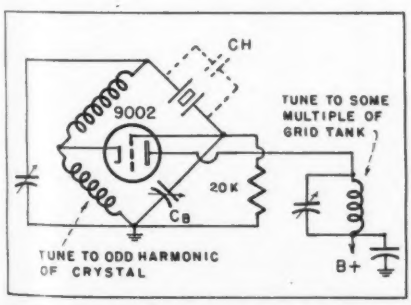
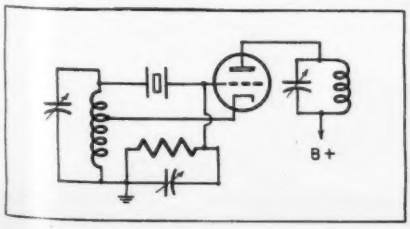


Fig. 5—Harmonic oscillator in bridge form

Fig. 6—Plate circuit tunable to harmonic



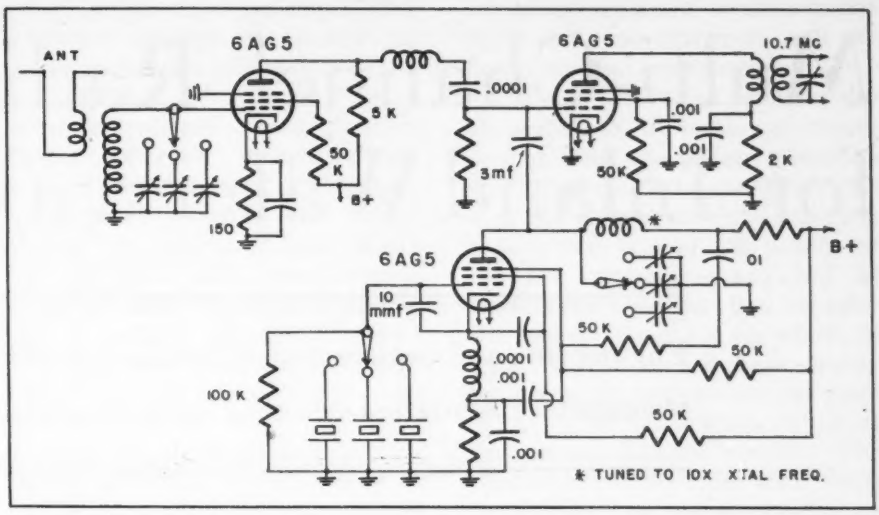
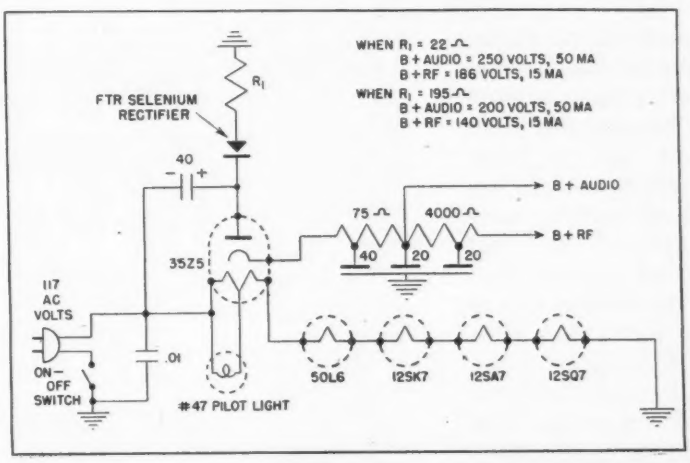


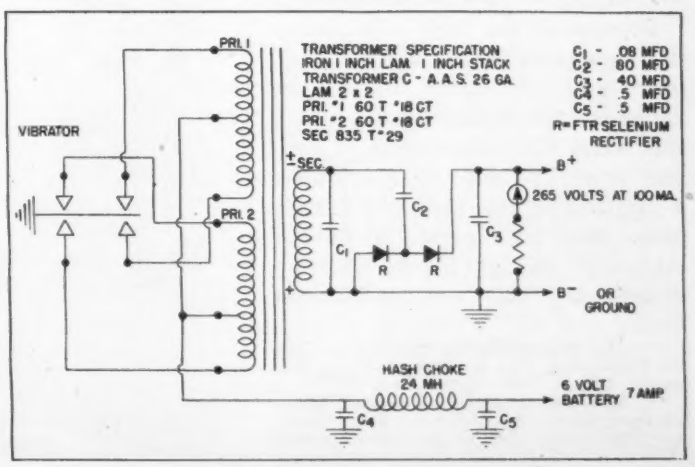
Fig. 4—Suggested circuit for economical application of pushbutton control to FM set

Selenium Rectifiers in Home Receivers

Comparatively recent development and large scale production of small, 5-plate selenium rectifiers has resulted in their adoption in one or more models of home receivers by over 30 set manufacturers, reports Federal Telephone & Radio Co. Illustrated are typical circuit arrangements for original use or replacement purposes.



Simple method of utilizing selenium rectifier in voltage doubling circuit to provide "B" power for combination radio-phono



Circuit and components suitable for design of vibrator power supply using selenium rectifier. Arrangement capable of efficiency of 60%

Multi-Channel Radiotelephone for Inland Waterways

By GEORGE G. BRADLEY
Engineering Dept.
Radiomarine Corp., New York

Engineering and constructional details of modern marine receiver-transmitter installation arranged for maximum service accessibility

SHIP to shore radiotelephone communication on the inland waterways and the Great Lakes involves certain special problems. This paper outlines these problems and describes a radiotelephone equipment which has recently been designed for this specialized service.

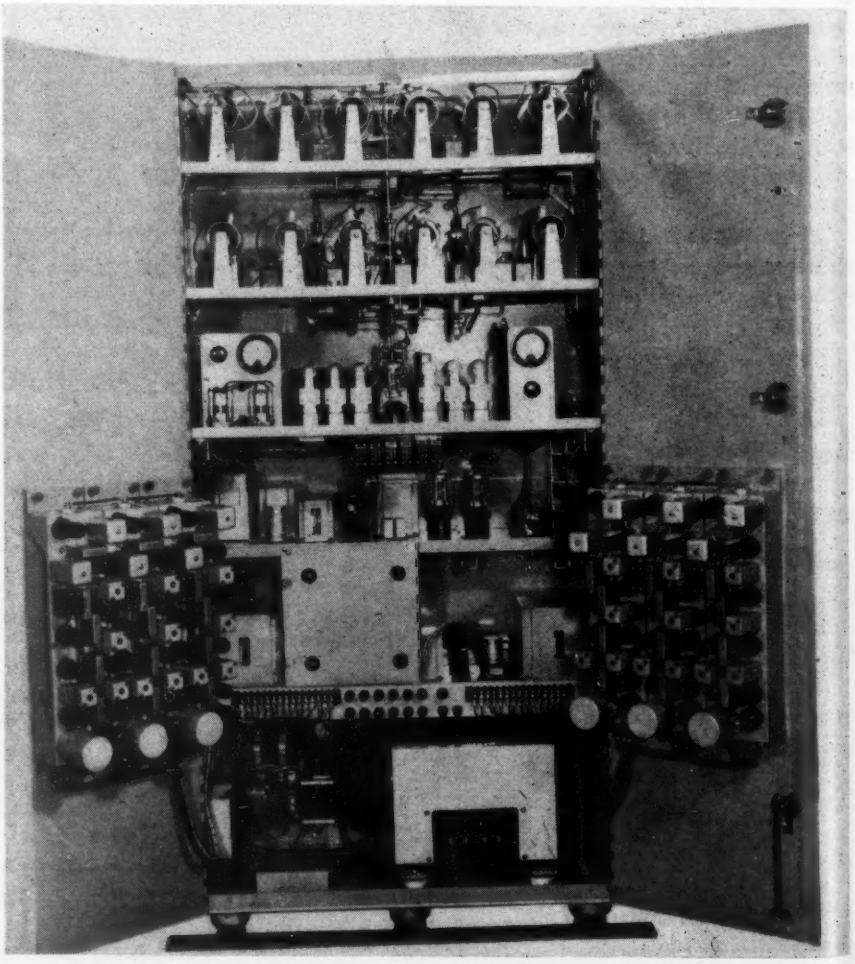
● Radiotelephone communication on the Great Lakes has been in extensive use for a number of years. By this means vessels may communicate with each other or with shore stations whose facilities are such that the subscriber aboard the vessel may be connected into the land-line telephone system. More recently, through the allocation by the Federal Communications Commission of additional frequencies,[1] a similar system has been inaugurated for use on the Mississippi River and its navigable tributaries.

Although the problems for radiotelephone communication on lakes and rivers are quite similar to each other they differ considerably from those encountered in the usual coastal harbor service which has been established at various ports located on the Atlantic, Gulf and Pacific Coasts of the country. Vessels operating in the harbors and in coastwise service have been allocated a group of frequencies in the 2-3 mc band, which, for the most part, give satisfactory service over a range of several hundred miles.[2]

Because of the high attenuation of frequencies in the 2-3 mc band over land and fresh water, the range is considerably less than over salt water for transmitters of similar power output. For example, a transmitter of 75 watts carrier power may be expected to have a maximum daylight range of from 50-100 miles where the transmission path is over land or fresh water and static is at low level.[3] However, for Great Lakes and river service a range as great as 800 miles may be required. To provide for daylight communication throughout this range the Federal Communications Commission has allocated channels in the 4, 6 and 8 mc bands as well as three channels in the 2-3 mc

[3] H. B. Martin, Great Lakes Radiotelephone Service, RCA REVIEW, Vol. IV, pp. 32-47.

Fig. 1—View of the transmitter-receiver cabinet with doors opened for servicing



[1] Federal Communications Commission Rules and Regulations, Part 8, Rules governing Ship Service, Oct. 1, 1939, Revised Page 15.

[2] C. N. Anderson and H. M. Pruden, Radiotelephone System for Harbor and Coastal Services, PROC. I.R.E., Vol. 27, pp. 245-253, April 1939.

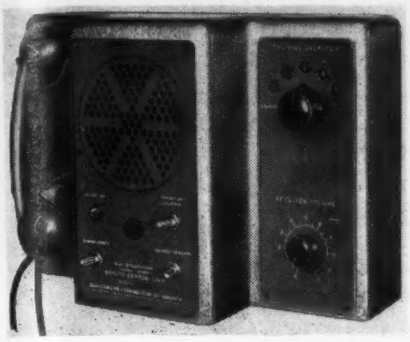


Fig. 2—Remote control unit showing channel selection switch controlling motor-driven gang switch at transmitter

band. Separate channels are provided for both the Great Lakes and the rivers.

Continuous monitoring of six channels simultaneously is necessary, with means for rapid frequency shift so that a call may be answered readily on any channel. Operation and control must be as simple and fool-proof as possible because the equipment is operated by non-technical personnel.[4]

As space for installing the equipment is seldom available aboard the vessel at the location where it will be used, complete remote operation is required. Often it is desirable that the equipment be operated from two different locations such as the bridge and the captain's quarters.

Two Major Units

Radiomarine Model ET-8031 is a 75-watt radiotelephone designed to meet the specialized requirements just outlined. The equipment comprises two major units: the transmitter-receiver cabinet and a compact remote control unit Fig. 2. The transmitter-receiver cabinet, Fig. 1, houses six separate receivers, one for each channel; a crystal controlled transmitter with provisions for switching to any one of six pretuned channels by means of a motor-driven gang switch; the transmitter modulator and speech amplifier; a selective ringer and the motor generator power supply.

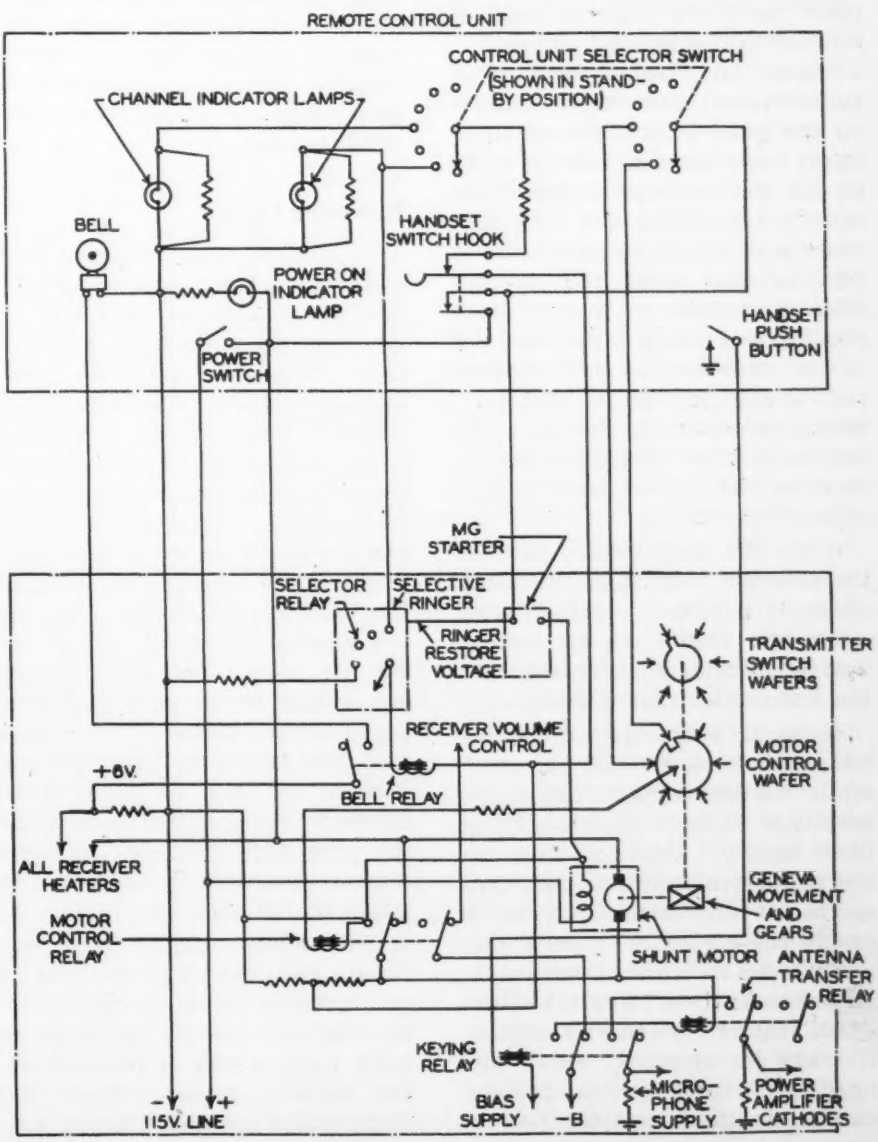
The remote control unit, Fig. 2, which is connected to the transmitter-receiver cabinet by means of two eighteen conductor cables, contains the channel selector gang switch, channel indicator lamps, a loudspeaker, volume controls and a bell for the selective ringer. The telephone handset is located on the front panel where it clamps into a standard switch hook. Front panel controls are a seven position Channel Selector Switch, a receiver Volume Control, a Handset-Loudspeaker Switch, a Power Switch and a Control Unit Selector Switch. When two control units are required in an installation, a junction box containing relays for switching control functions from one control unit to the other is also required.

Operation of the ET-8031 is very simple and takes place entirely at the remote control unit. Power for both transmitter and receiver is controlled by the power switch, a blue indicator light showing when the equipment is energized. When the channel selector is in the standing position all six receivers are functioning and signals on the three 2-3 mc channels will be heard on the loudspeaker.

The 4, 6 and 8 mc receivers are connected to the selective ringer so that when the vessel's telephone number is dialed by the shore station, the control unit bell will ring. In addition, one of the numbered channel indicator lamps will be illuminated showing the operator the correct channels on which to reply. Any of the six channels may be monitored individually by placing the channel selector switch at the desired channel number. The circuits are so arranged that, while monitoring any one of the 2-3 mc cycle channels, the three high frequency channels remain connected to the selective ringer.

To place a call, the user merely picks up the handset and moves the channel selector switch to the

Fig. 3—Simplified schematic of control circuits showing channel selection method



[4] Federal Communications Commission, Rules and Regulations Part 13, Rules Governing Commercial Radio Operators, July 1, 1939.

desired channel number. As soon as the transmitter circuits have been switched by the motor-driven gang switch, a matter of three seconds or less, the channel indicator lamp will be illuminated and the transmitter is ready to go on the air, the carrier being keyed by means of a pushbutton located in the handset.

Control Circuits

The control circuits of the ET-8031 are designed around the motor-driven transmitter channel selector gang switch. A simplified schematic diagram of these circuits is shown in Fig. 3. Individual wafers connect the correct crystal as well as the pretuned oscillator, power amplifier and antenna circuits for the desired operating frequency. This gang switch, which is equipped with a detent mechanism, is driven by a geneva movement, the driver plate of which is coupled to the motor by means of a worm and pinion gear. The motor control pilot wafer contacts on the gang switch connect to a single contact, seven position wafer on the channel selector switch located in the control unit. The pilot wafer is of the single open contact type so that when the channel selector switch is moved from standby to a channel position, the motor control relay is energized and the motor drives the gang switch around until the open circuit contact on the pilot wafer arrives at the correct position and stops the motor.

When the gang switch stops at the selected position, a numbered channel indicator lamp located above the switch on the control unit is illuminated, showing that the transmitter is now ready.

Additional contacts on the handset switch hook energize the automatic starting relay for the motor generator which is the transmitter plate supply. Collector rings on the motor armature are used as a source of alternating current to supply the filaments of the transmitter tubes through suitable transformers. As these tubes are of the quick heating type the transmitter is ready for operation within approximately three seconds after the handset is lifted from the hook.

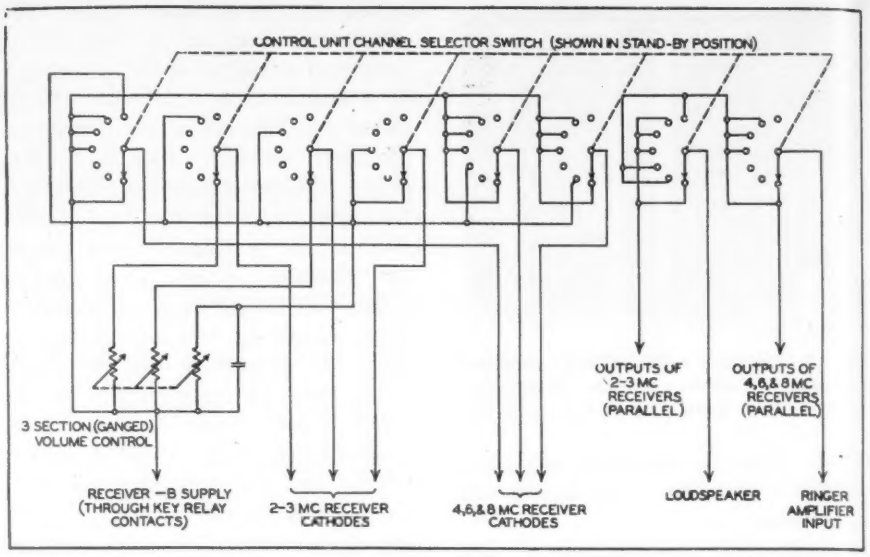

CONTROL UNIT CHANNEL SELECTOR SWITCH (SHOWN IN STAND-BY POSITION)
3 SECTION (GANGED) VOLUME CONTROL
OUTPUTS OF 2-3 MC RECEIVERS (PARALLEL)
OUTPUTS OF 4,6,& 8 MC RECEIVERS (PARALLEL)
RECEIVER —B SUPPLY (THROUGH KEY RELAY CONTACTS)
2-3 MC RECEIVER CATHODES
4,6,& 8 MC RECEIVER CATHODES
LOUDSPEAKER
RINGER AMPLIFIER INPUT

Fig. 4—Schematic diagram of the receiver switching unit covering all six channels

Receiver switching is accomplished by making use of the remaining wafers of the control unit selector switch. These are shown schematically in Fig. 4. As three channels are monitored simultaneously on the loudspeaker when the channel selector switch is in the standby position, a three gang gain control is furnished for controlling volume.

Indicator Lights

A so-called radio frequency type gain control circuit is used whereby the introduction of resistance in the common cathode lead of the radio frequency and first intermediate frequency amplifier of the receiver decreases its sensitivity.

The gain control circuits of the three high frequency receivers are connected to the negative of the receiver power supply so that these receivers are operated at full gain into the selective ringer. Moving the selector switch to one of the 2-3 mc cycle channels connects one section of the gain control to the desired receiver. The other two low frequency receivers are silenced by open circuiting their respective gain control leads, while the three high frequency receivers remain connected to the selective ringer at full gain.

The channel indicator lights previously mentioned also are used as call indicator lights to indicate to the user the channel on which to reply when a call is received via the selective ringer. When the shore station operator dials the vessel's telephone number, a contact closes in the selective ringer and energizes the bell relay in the transmitter-receiver cabinet.

There are three additional contacts on the selector relay in the ringer unit which close in sequence as the operator dials 2, 4 or 6 impulses after the bell rings. These contacts are connected in series with three channel indicator lamps in the control unit with the bell relay still in the circuit. The contact on which the selector relay comes to rest thus lights the lamp showing the channel on which a reply is expected. The bell continues to ring and the lamp stays illuminated until the shore station dials a restoring impulse or the operator raises the handset from the switch hook applying a restoring voltage to the selective ringer.

In case two remote control units are installed aboard the vessel a junction box is required with the extra control unit. The junction box contains three relays whose function is to switch the various control circuits from one control unit to the other. Fig. 5 is a simplified diagram of the connections.

Additional contacts, not shown on the diagram, switch the gain control, audio, and other necessary circuits to the selected control unit. Thus the user may place or receive a call at either control unit regardless of which unit has initiated control at the time. A lockout relay is provided in the junction box which is energized when the handset is lifted from the hook.

Thus, when a call is in progress at one control unit, the other unit is dead and manipulation of any of its switches cannot interrupt the user making the call at the first control unit.

Beam Power Tubes

The transmitter itself is fairly orthodox in design. RCA type 1624 beam power tubes are used throughout for both the radio-frequency and audio-frequency circuits, a single 1624 being used as the quartz crystal controlled oscillator and four of these tubes connected in parallel as the power amplifier. Separate tuned circuits are provided for pretuning the oscillator, power amplifier and antenna for each channel and are connected to the radio-frequency tube circuits by means of motor-driven gang switch previously described. Individual wafers on the switch short out the tuned circuits of the unused channels.

Coupling between the power amplifier and the antenna tuning circuit is inductive and is achieved by means of a low impedance shielded link directly connected to the antenna tuning inductor and the power amplifier plate inductor.

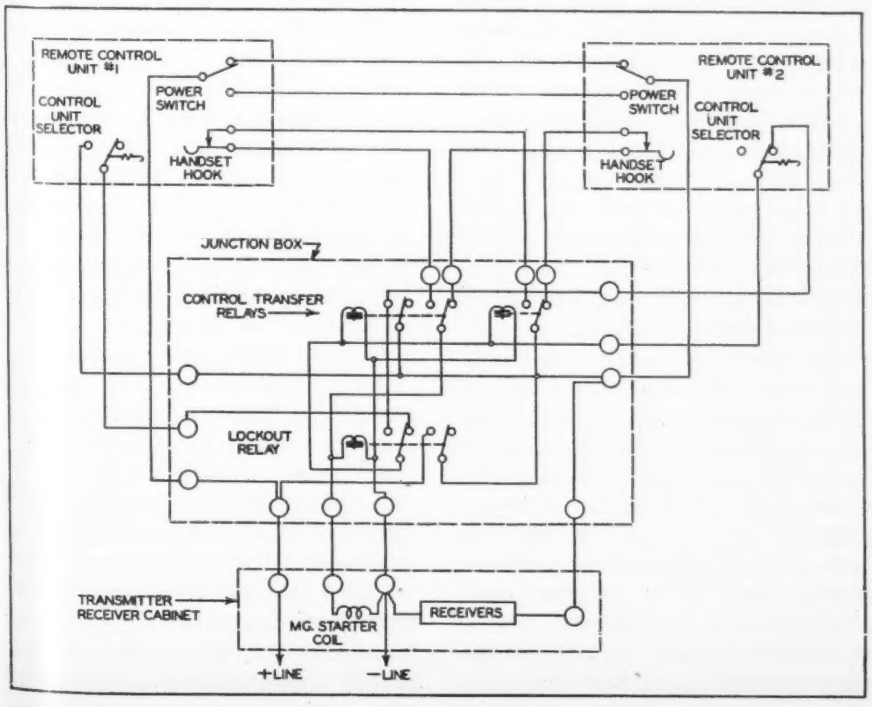
Antenna space aboard the vessels plying the inland waterways and the Great Lakes is usually limited. Thus, the ET-8031 is designed to operate into an antenna from 35 to 60 ft. long which is less than a quarter wave in the 2-3 mc band and must be series loaded with inductance to achieve resonance. Using a dummy antenna of 200 micromicrofarads and a direct current resistance of 12 ohms the transmitter carrier power output is 75 watts or more at the operating frequencies between 2182 and 8840 kc. This carrier can be 100% modulated with less than 6% distortion at 1000 cycles.

Four 1624 tubes connected in push-pull parallel and operated class AB_2 are used to plate and screen modulate the power amplifier. The driver stage consists of two 1624 tubes operated in push-pull class AB_1 and transformer coupled to the modulator grids.

Frequency selective inverse feedback is used across the driver stage to minimize distortion when the modulator grids are driven positive and to attenuate frequencies above 3500 cycles.

The transmitter is completely powered by a motor generator operating from the 115-volt direct current line and having an output of 570 volts direct current. This voltage is used for the plate supply of all the transmitting tubes with the exception of the driver stage which obtains its plate supply from a voltage dividing network also used to supply the modulator screens. The power amplifier screens, however, are supplied through a series dropping resistor. In addition to the two filament transformers operating from the collector rings on the motor armature a third transformer is used as a source of bias supply. This transformer connects into a magnesium-copper-sulphide fullwave bridge rectifier and its filtered output connects to the bias network. A combination of fixed and grid leak bias is used for the power amplifier, the bias being adjusted so that the plate dissipation of the power amplifier tubes is not exceeded in case grid excitation is lost. The bias network also provides the necessary fixed bias for the modulator and driver stages.

Fig. 5—Remote control transfer and lockout circuit used with multiple control units



Plug-in Receivers

The individual receivers are designed so that they may be plugged into sockets located on the doors of the transmitter-receiver cabinet.

With the exception of frequency range each receiver is identical. Three receivers have a range of 2 to 4.5 mc, while the other three receivers cover the 4 to 9 mc band. Nine tubes are used in a crystal controlled superheterodyne circuit having a 6SG7 radio frequency amplifier, a 6SG7 triode connected oscillator, a 6SA7 mixer, two 6SG7 intermediate frequency amplifiers, a 6SQ7 detector and first audio-amplifier and a 25L6 audio-output tube. In addition, a 6SG7 is used as an automatic volume control amplifier and a 6H6 functions as the automatic volume control rectifier and series noise limiter.

Plate voltage for the receiver tubes is obtained directly from the 115-volt direct current line. An audio-frequency, low pass filter section in each side of the line reduces the supply ripple to a minimum. As the positive side of the line supply might be grounded externally, it is not possible to ground the negative supply in the receiver. Consequently, extreme care in the design of the receiver was necessary to prevent oscillation. The use of relatively large size by-pass capacitors strategically placed plus careful consideration of the wiring layout finally overcame this difficulty.

(*Continued on page* 147)

Railroads Plan Greater Us

Most passenger and freight rail carriers, experimenting with space and inductive systems, expect big increase

By JOEL PETERSON
Assistant Editor, Tele-Tech

A Bendix ground-plane antenna atop a Santa Fe streamliner equipped with two-way radio communication gear

• Railway radio like many other branches in the expanding field of communications, is now undergoing a phase of postwar acceleration. While the direct activity of the railroads in the field of radio is probably greater than it ever was, the general consensus of the railroad people is that rapid wide scale adoption may take a number of years. A long and slow process of development and experimental tests must be performed by both the railroad companies and the radio equipment manufacturers in order to arrive at a satisfactory solution to the problem.

This is not to be construed as a failure on the part of the railroads to recognize the importance of radio for operational use, but rather as a general policy of watchful waiting until operational experiments indicate the most efficient modes of use and until manufacturers can design suitable equipment.

Some railroad companies have been interested in the application of radio to various railroad problems for many years, in several cases as far back as 1917. At present the total installed radio equipment for railway operations represents a small fraction of the potential market, but steady progress is being made to meet the growing demand.

The recent public clamor urging the railroads to install radio communication has not stimulated the railroads so much as it has the manufacturers of radio equipment who have recently engaged in a heavy advertising campaign that in some respects exceeds the present development of railway radio. The curious fact is that the late public agitation was in the interest of railroad safety, whereas the railroads are using or shortly expect to use radio for railroad operations which are distinct from the present system of signaling for safety purposes. Recent opinions of the Interstate Commerce Commission bear out the contention of the railroads that despite accusations to the contrary, present signaling methods are adequate for safety precautions, and that the immediate advantage of radio lies in the improved efficiency that is gained in routine railroad operations. Railway radio is apt to make slower progress than is anticipated in some quarters because radio communication equipment especially adapted to railroad uses is not available in sufficient quantity. While some manufacturers hope to design a railway radio set that can be universally applied to to all American railroads, it is the opinion of a number of railroad officials that equipment must be tailor-made to fit the various types of railroad service.

Watchful Waiting

On the smaller railroads, the general policy is one of watching and waiting for types of equipment tested for technical design and operational efficacy. Many of the smaller railroads will look to the larger ones to serve as the laboratory for railway radio tests and will initiate action only when the installation of such equipment can be shown to yield dividends in money savings and improved efficiency commensurate with the amount of investment.

In the particular case of one small railroad operating on the east coast, the recent publicity campaign served only to make this company more cautious about taking immediate steps into railway radio. This company briefly reflected back to a similar story about a new product that received the same type of advertising campaign a number of years ago. On the surface, it appeared that the new device would

# of Radio for Communications

enjoy a good market, and inexperienced manufacturers turned out equipment that could not stand up to the rugged treatment resulting from moving trains. Of approximately 15 companies that vied for orders from the various railroad companies only two are still manufacturing this equipment, the others having miscalculated the cost of development with respect to the market value, dropped out of the picture. The present status of railway radio is somewhat similar.

Railway equipment is now being manufactured by railway signal companies as well as radio equipment companies, and only time will tell whether the railroads will favor one or the other or possibly both. This point is elaborated on because the railroads feel it is most important that a manufacturer whose equipment they are now using will be in business when they are ready to replace in the future.

Like the railroad companies, manufacturers of communication equipment entertain mixed attitudes and policies toward railway radio. While many manufacturers are now engaged in an all-out effort to capture the market, others are merely in the process of slow development, watching closely the results of current tests. The general policy indicated here is that no attempt will be made to convert any radio equipment that has been used for other purposes into makeshift railway radio. They are waiting in fact for the railroads to set up specific demands on the manufacturer. Despite the many advantages of railway radio, the railroad companies do not intend to install equipment until a definite saving in time, money and improvement of efficiency can be shown on the company books.

The recent development of high frequency equipment coupled with use of frequency modulation have overcome many of the handicaps that railroads have found with radio since they first looked into this means of communication thirty years ago. At any rate certain railroads now have actual radio installations or equipment on order. Others are in the process of testing and developing radio equipment for future use.

Types of Radio Communication

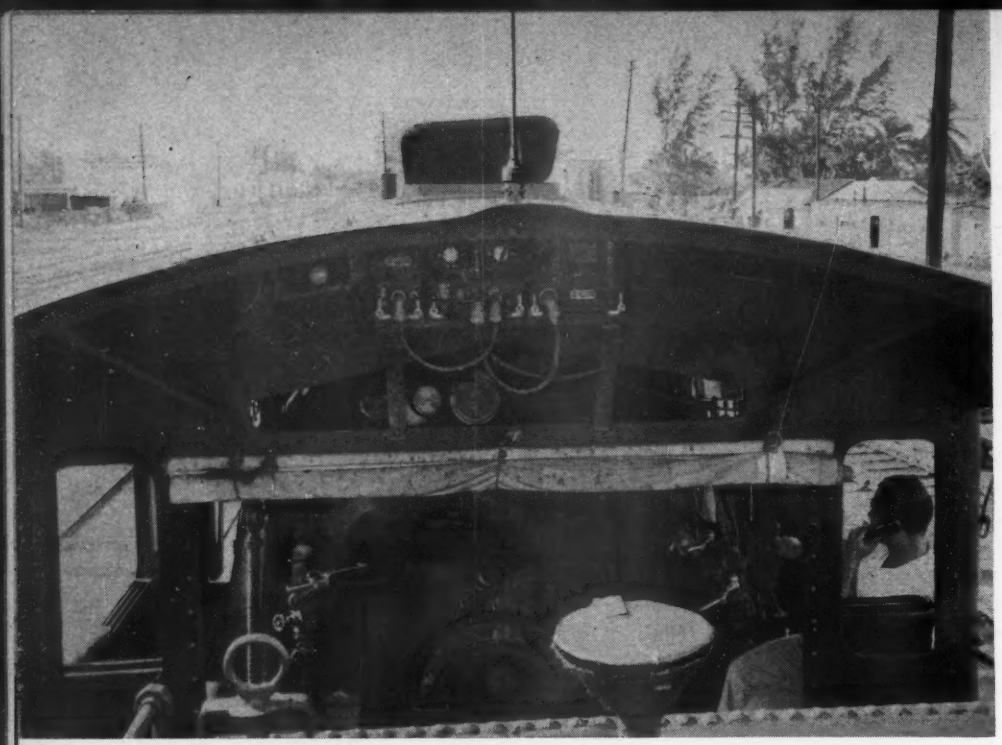
There are two main types of railway radio equipment being developed and manufactured at present. One is the carrier or inductive type of communication that makes use of wayside wires or bonded rails along the right-of-way as the medium of transmission. The other type is known as space radio communication and refers to point-to-point communication using the ether as the transmission medium. Development has not gone far enough to indicate which type will prevail over the other or whether both the inductive and the space types of radio in combination will be the final solution.

In general, the inductive type of communication covers longer distances than does space radio but since it dictates that the railroad right-of-way have wayside wires within the range of desired communication, it is impractical for yard, terminal or harbor use. While space radio uses no wires, the range of communication is considerably less at the frequencies generally in use. Railroads that have inadequate wayside wires along the right-of-way probably will turn to the space radio type of communication, although some systems have used the rails as the medium of transmission. The indications are that both the inductive and the space types of radio service will find uses in the railroad industry depending on local conditions. Since the space radio type of service can be applied where the inductive radio is impractical, the former will probably have wider application.

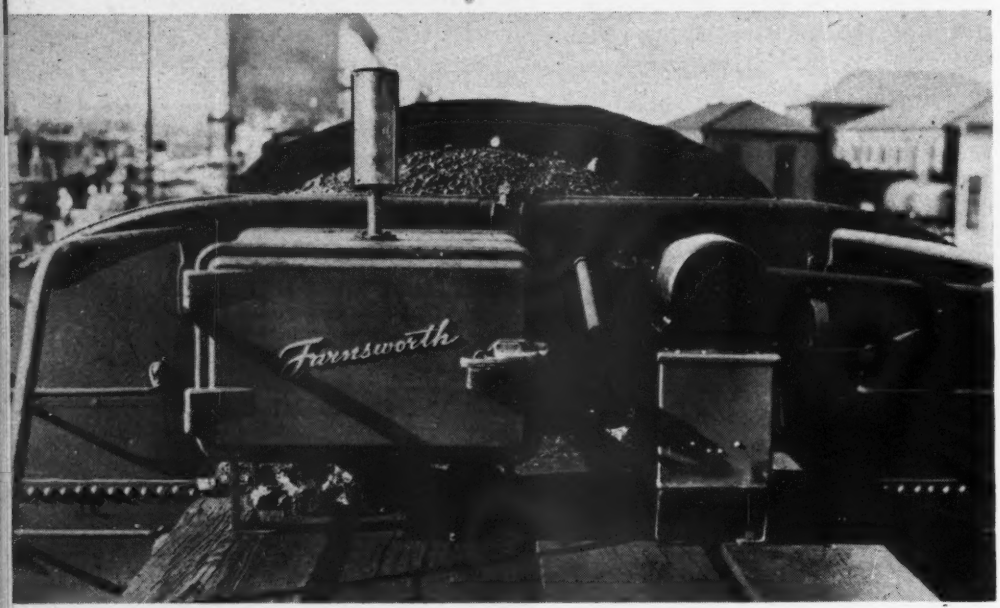
The different types of railway radio services have been variously classified as end-to-end, train-to-train, point-to-train, warehouse-to-tug, tug-to-tug, etc. Another classification of railway communication services breaks down into four general types: (1) Intra-mobile, (2) Inter-mobile, (3) Fixed station-to-mobile and (4) Fixed station-to-fixed station. Intra-mobile service specifically refers to communication between the two ends of the same train. Inter-mobile service is point-to-point communication between two trains, two harbor tugs, train and tug, train and walkie-talkie or tug and walkie-talkie. Fixed station-to-mobile and fixed station-to-fixed station types of service are self-explanatory.

The end-to-end type of radio communication is one that solves

A Pennsylvania railroad trainman totes a Union Switch & Signal portable transceiver and talks with other trainmen via wire inductive carrier



Florida East Coast Railway company radio installation showing equipment location and mobile antenna. (manufactured by the Communications Company, Florida)



An installation on a Nickel Plate locomotive tender illustrating the Farnsworth "firecracker" type mobile antenna as well as the weatherproof radio set housing

A Chicago and Northwestern Railway two-way radio installation on the locomotive tender showing a Bendix ground-plane antenna and two weatherproof radio housings

many problems that arise during the operation of the train. In this system a radio set is installed in the locomotive and another is installed in the caboose, enabling the locomotive engineer and the caboose personnel to maintain contact with each other. A moving freight train develops such troubles as hot boxes, sticking brakes, loss of braking system air pressure, car decoupling, etc. The end-to-end radio facilities will enable the trainmaster in the caboose immediately to notify the engineer at the train head and provide for quick stopping before damage results. This type of service saves time in warning crew members, sorting out cars, siding operations and where hand signals are difficult to execute in bad weather or winding terrain.

Radio for Dispatching

The use of radio in terminals is another important application. In this case two-way radio enables the dispatcher's office to maintain contact with trains that leave the main line and enter many different industrial sidings and depots. Radio enables the dispatcher to issue new instructions to arriving or departing trains. When it is necessary to instruct the locomotive engineer of any last-minute requests of the shipper, radio provides improved service.

In classification yards, known as humping yards to the trade, radio installations have resulted in considerable improvement of operational efficiency. Various cars of a freight train are segregated by allowing certain cars to be disengaged and roll down the hump slope to different track sections. In this case the yardman on the hump is equipped with a portable set and is in constant touch with the engineer who is a half to a mile away depending on the length of the train. The present system of signaling for hump operations transmits only three signals, "proceed", "stop", and "slow". Radio enables the transmission of precise and continuous instructions and speeds up operations considerably.

The present frequency assignment plan for railway radio as prepared by the Association of American Railroads is set forth in AAR

report M-2375. This plan comprises 60 channels, 60 kc apart in the 158-162 mc band. However, action is now pending to assign channel numbers 45, 46 and 47 to the Mobile Maritime Service.

For the end-to-end type of communication it is contemplated that radio sets installed in both the locomotive and the caboose will operate on the same frequency. The plan provides one frequency for each railroad system for use in this type of communication.

In making assignments for point-to-train radio communication it is contemplated that one frequency shall be used on all wayside stations along the right-of-way and these will transmit to a special receiver in the caboose. The caboose can then transmit back to the wayside station on its end-to-end transmitter or relay any information from the wayside station to the locomotive. It is necessary that the end-to-end and point-to-train frequencies assigned to any particular railroad be separated as much as possible to prevent interference. This is only one method of using frequencies in the end-to-end and point-to-train types of radio service. Other plans have been tried and are now being developed. Eventually the Federal Communications Commission in cooperation with the railroads will choose those plans which will conserve the assignment of frequencies, and at the same time satisfy the needs of the railroads.

Channels Available

At present, there are only six point-to-train frequencies (channels 1, 12, 20, 24, 36 and 44); therefore, the assignment of these frequencies will require careful testing to insure satisfactory operation without interference. The plan specifies that each railroad will be assigned one of these six point-to-train frequencies and where interference is experienced in certain sections with other railroads, another frequency may be used in that area.

With respect to frequency assignments for radio communications in yards and terminals, it is recognized that under some conditions of operation it would be desirable that the frequencies assigned be sufficiently close together so that easy change can be made from one to the other by pushbutton operation. An attempt will be made to do this; however, it is not always possible to assign frequencies which would fulfill this requirement because of the limited number.

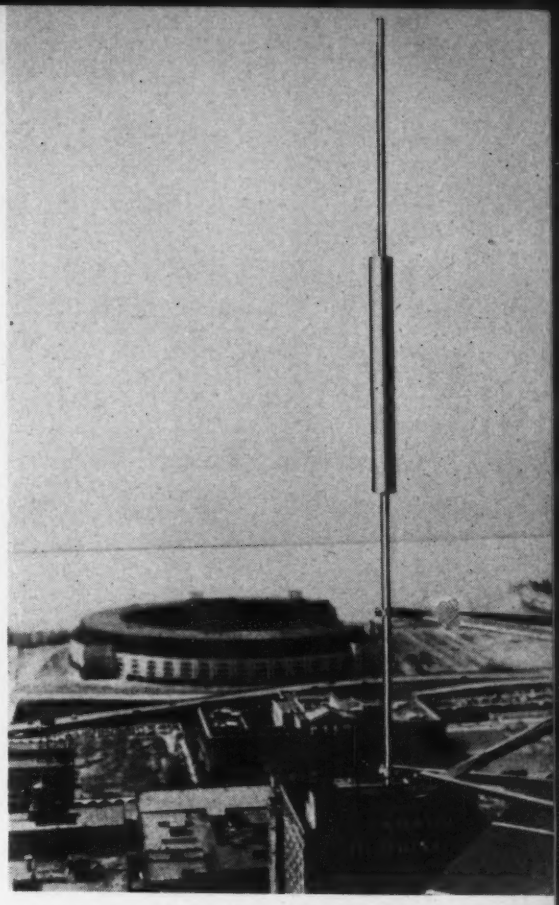
Up to May 1946 the Federal Communications Commission had authorized the operation of experimental and railroad radio stations in the 152-162 mc region to the following railroads: Atchison-Topeka & Santa Fe, Baltimore & Ohio, Chicago - Burlington & Quincy, Chicago - Milwaukee - St. Paul & Pacific Railroad Co., Chicago-Rock Island & Pacific, Denver & Rio Grande Western Railroad Co., Florida Coast Railway Co., Jacksonville Terminal Co., the Missouri-Pacific Railroad, New York Central, Northern Pacific Railway Co., Pere Marquette Railway, Seaboard Airline Railroad and Union Pacific Railroad.

Pennsylvania's Plans

Culminating a 20-year pioneering period of research and development into the use of radiotelephone communications, the Pennsylvania Railroad will soon complete a large scale permanent system on its four-track main line between Harrisburg and Pittsburgh, Pa. In collaboration with the Union Switch & Signal Co., the Pennsylvania system is a combination of inductive radio and wire lines covering 319 miles of main line including 1,056 miles of main trackage at a cost of approximately one million dollars.

When the installation is completed the railroad will have mobile units installed in 150 passenger locomotives, 131 freight locomotives and 100 cabooses. These will operate in conjunction with 16 land stations set up in wayside control towers along the right-of-way. In future requisitions for new locomotive equipment, the Pennsylvania Railroad will specify that each new equipment be equipped with mobile radiotelephone sets.

Approximately 17 years ago the Atchison-Topeka & Santa Fe began its first test in radio for railroad use. At that time the company was searching for a means of communication between the yardmaster and the switching crews in



A fixed-station coaxial type antenna

Above: Western Electric conducted tests with this 14-inch antenna in cooperation with the Northern Pacific. Below: A GRS installation on a NY Central tender

A Pennsylvania Railroad photo illustrating the inductive pick-up coil in the projecting bar just behind the wheel and under the piston head

the far-flung yards at Los Angeles. A radio test was arranged and because of inadequate equipment and poor operating frequencies, it was found to be impractical.

In the early part of 1944 the Santa Fe opened negotiations with the Bendix Corp. with a view to working out a reliable system of radio communication for trains. Bendix manufactured the equipment which was of the amplitude modulated type and the installation has been used ever since. A modified turnstile type of antenna 24 in. high was used on both the caboose and the locomotive. In this particular case, the use of amplitude modulation and a medium high frequency provided satisfactory communication even when the mobile transmitters were in tunnels. The radio equipment located on the engine was operated from a 24-volt storage battery which was charged from a 32-volt headlight generator. The same type of power supply was used on the other end.

Union Pacific has recently completed a two-way radio installation in its Kansas City terminal using Motorola equipment. Mobile radio sets are mounted on 16 diesel switchers. A fixed station with 50 watt transmitter and an antenna 122 ft. high is used by the yardmaster. The equipment uses frequency modulation and operates on approximately 162 mc. In the Kansas City industrial area the range of the fixed station is approximately 12 to 15 miles. The cost of installation was placed at $25,000 by the Union Pacific's Superintendent of Telegraph, and is considered a comparatively small investment for the amount of work done and time saved.

Another recent two-way installation has been made in the Dallas yard of the Texas & Pacific Railroad. The equipment is manufactured by the Farnsworth Television & Radio Corp. and has been installed on three locomotives and in a central fixed station. The fixed station is operated from two remote control points, one in the downtown office of the Superintendent of Telegraph and the other in the Assistant Yardmaster's Office in the yard. The radiotelephone system is designed to facilitate switching and loading operations in that area.

Space and Carrier

The New York Central Railroad has conducted tests in cooperation with the General Railway Signal Co. and the General Electric Co. in space and carrier communications. The test facilities consisted of two steel laboratory cars each equipped with a complete carrier and space radio system. The purpose of two laboratory cars was to place one at the locomotive and the other next to the caboose in the end-to-end communication test. Power was transformed from the 32-volt supply to 117-volt 60-cycle ac by means of rotary converters. The carrier and space radio systems were independent and could be operated simultaneously.

For the space radio system a quarter-wave whip antenna was mounted on the car roof. For the inductive system a loop consisting of insulated stranded No. 10 copper wire was strung on brackets mounted on the roof top. The space radio equipment operated on a frequency of 160 mc using frequency modulation with an output of 15 to 20 watts.

The mobile inductive communication equipment consisted of a frequency modulated transmitter operating on a frequency of 150 kc with an output of approximately 35 watts. The transmitter and the receiver in the mobile unit used the same loop for an antenna. The point-to-train results on the space radio test were generally satisfactory. The satisfactory operating ranges were dependent on the terrain as well as type and height of antennas at the fixed station. One fixed station used a coaxial antenna 50 ft. high and covered a range of 12 to 15 miles satisfactorily in hilly terrain.

Carrier Results

As a result of the carrier radio test it was found that the lower frequencies suffered less attenuation and a number of tests were made on a frequency of 88 kc. The range for good two-way communication on open wire lines was approximately 50 miles and reduced to 15 miles where lines went into cables. End-to-end communication was generally solid except where wire lines went into cables or diverged away from the track.

The Florida East Coast Railway operating between Jacksonville and Miami, Florida, has installed two-way FM space radiotelephone communication at its Miami terminal. The equipment was manufactured and installed by the Communications Co., Inc., Coral Gables, Florida, and operates on a frequency of 160 mc. A fixed station is located at the yardmaster's office and mobile units are mounted just under the hood of the locomotive tender. The installation is designed to eliminate the usual terminal delay and to improve the service of all freighting facilities. Quick switching, shifting of cars from track to track, and fast dissemination of instructions results from the installation.

The Chicago and Northwestern Railway conducted a test in June 1946 with Bendix equipment between Proviso and Council Bluffs. The frequency was 158 mc and the sets were frequency modulated. Tests were made on the end-to-end type of communication on a freight train of approximately 110 cars. A representative of C&NW confirmed a previous contention that it is possible to save an average of one hour and 15 minutes in running time between Proviso and Council Bluffs.

The train crews agreed that the radio equipment speeded up operations and simplified the execution of duties. It was reported that the equipment worked very well and that a range of approximately 15 miles between the wayside station and the mobile station was possible with satisfactory communication.

FM Holds Promise

In July of 1946 the Nickel Plate in cooperation with the Farnsworth Radio & Television Corp. conducted a series of tests on radio communications in the Indiana, Ohio boundary area. The Farnsworth equipment was frequency modulated and operated at 161 mc with an output of 10 watts. A ground plane type of antenna was used in conjunction with the Farnsworth equipment in the mobile unit. With a fixed station antenna height of 60 ft. above ground, up to 14-16 miles of radio range was obtained in flat terrain. One fixed station antenna was mounted on a tall building about 600 ft. above ground and provided an increased range of from 30 to 38 miles. In the greater Cleveland area satisfactory communication was maintained between the train and the tower except for short intervals at several points when the locomotive passed under a bridge structure or intervening tall buildings disrupted the direct path.

The Southern Pacific Coast Division, in cooperation with Westinghouse, conducted radio tests in August 1946 in Southern California. The Westinghouse equipment was of the frequency modulated type and operated on a frequency of 161 mc with an output of 25 watts. A ground-plane quarter-wave antenna was used on the mobile unit. The power supply was 32 volts dc. The fixed station antennas were 60 ft. above ground and the average range was 21 miles. Communication in this case was very good in spite of intervening mountains. The general reports are that the consistency of reception between two stations depends to a large degree on the type of terrain and the height of the fixed station antennas.

In May of 1946 the Aireon Mfg. Corp., Kansas City, demonstrated

(*Continued on page* 150)

An engineer answers a call from the dispatcher in the Haskell & Barker industrial yard using Motorola equipment (a central station and six mobile units)

(Left) A New York Central trainman talks with the locomotive engineer using General Railway signal equipment for "humping" operations in a classification yard. (Right) A typical wayside radio installation on one New York Central line

Design of 500 kc Transformers

By REUBEN LEE, Advisory Engineer, Westinghouse Electric Corp., Baltimore, Md.

Development of laminated iron-cored transformers for use at carrier frequencies simplifies power line communications equipment

UNTUNED iron-core transformers are used in power-line carrier equipment to match outputs to lines or other leads, to avoid tuning complexities and adjustments, and to simplify division of load between circuits. The lowest carrier frequency is 50 kc and the highest intermediate frequency (in superheterodyne reception) is 515 kc. Transformers which operate over the range of 50 to 515 kc find a multitude of uses in such equipment.

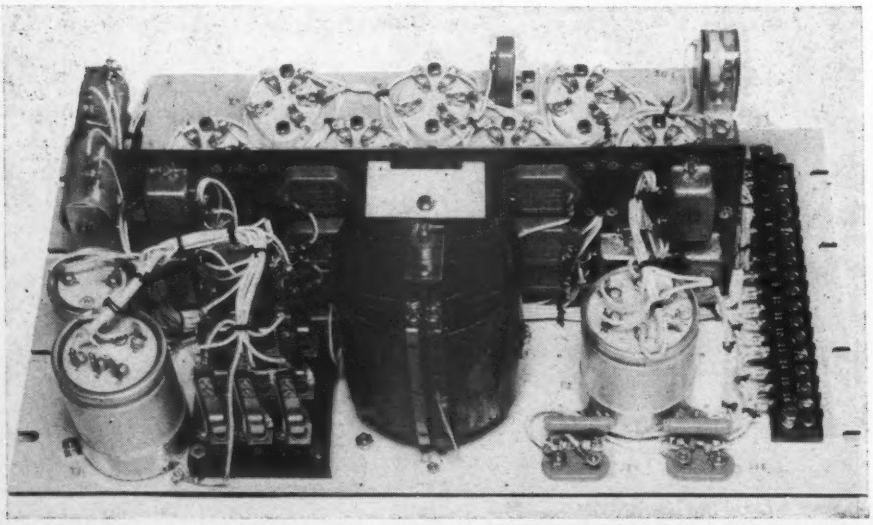
● Success in making 500 kc transformers depends upon care in the case of new materials and attention to frequency response fundamentals. Like other amplifiers, the performance of a carrier amplifier is limited to a certain range of frequencies. The frequency response curve of Fig. 1 may be drawn for any amplifier in general.

The first part of the curve has poor response at the lowest frequencies and is labeled Rise. As frequency increases, the curve slopes less and becomes nearly flat. This part of the curve is labeled Incipience. As frequency increases further the response is uniform over the range of frequencies so marked. At the end of this frequency interval the curve declines somewhat and is marked Decline. At still higher frequencies, the curve falls to a low figure and is marked Fall.

In general, the regions of rise and fall are not useful. The value of response at which these regions terminate is governed by the amplifier requirements. In an audio amplifier for broadcast studios, for example, the uniform region is very wide and extends over most of the range of 30 to 10,000 cycles. Moreover, the regions of incipience and decline end at about 1 db, and may take in all frequencies from 10 to 30,000 cycles.

In a given amplifier, the factors governing the rise and incipient part of the curve are shown in Fig. 2. The source resistance R_1, the transformer open circuit reactance and load resistance R_2 are related as shown for the condition of $R_2 = 2R_1$. This corresponds to a triode output, wherein the tube works into twice its internal resistance. X_s is $2\pi f$ times the transformer open circuit inductance (OCL), where f is the operating frequency. The greater the transformer OCL, the better the response at low frequencies.

Fig. 7—Rear of 500 kc amplifier panel (output transformer is in round case at right)



Winding Impedance

To obtain high OCL requires magnetic material of high permeability, and sufficient turns to produce the required inductance. High OCL could also be obtained with poor magnetic material if more turns were used, but this is bad in a transformer with extended frequency range, because the leakage inductance and distributed capacitance increase, and adversely affect the high frequency response.

Fig. 3 shows how these factors combine to cause a droop in response at high frequencies for the case of a triode output transformer. In this figure, R_1 and R_2 have the same meaning as in Fig. 2. At frequency f_r the reactance of the leakage inductance and winding capacitance are equal, and the ratio B of either reactance to the source re-

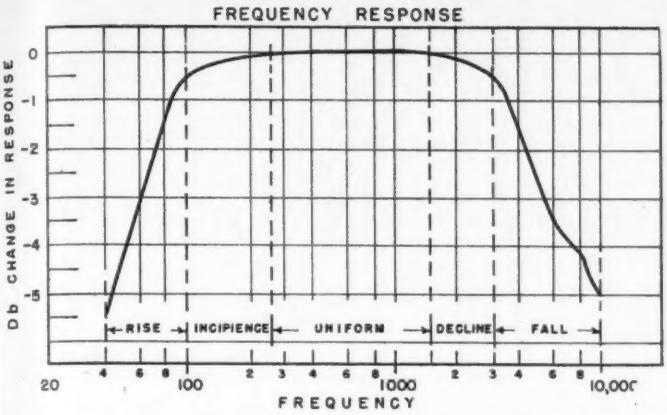


Fig. 1—Frequency zones used in analyzing carrier response

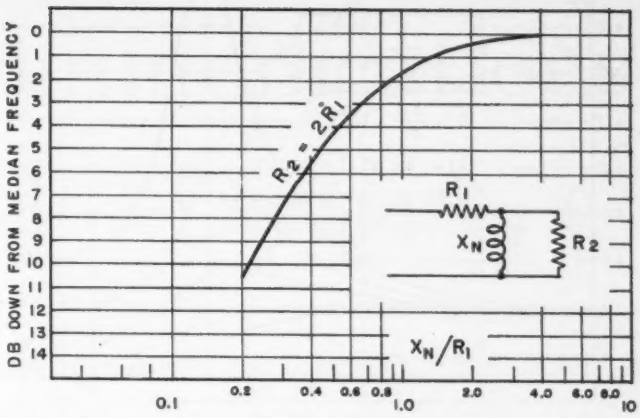


Fig. 2—Low frequency response with load twice tube resistance

sistance R_1 is the parameter for the curves. Values of this parameter nearly equal to unity are obviously helpful in obtaining good frequency response. This means a balance between leakage inductance and winding capacitance and requires careful design.

For voice frequencies of approximately 300 to 3000 cycles, the uniform response range is narrow, and may even shrink to nothing so that the response curve is first either incipience or decline. The transformer for an amplifier of this sort may have less OCL, and increased leakage inductance and winding capacitance compared to a transformer for a wider band amplifier.

A similar ratio of minimum frequencies obtains in a carrier frequency transformer. The transformer properties therefore resemble those of the voice frequency transformer in that the ratio of OCL to leakage inductance is less than for the wide band amplifier. There is this difference, however, that both OCL and leakage inductance are approximately 1/100 of the like properties in a voice frequency amplifier, for the same circuit impedance.

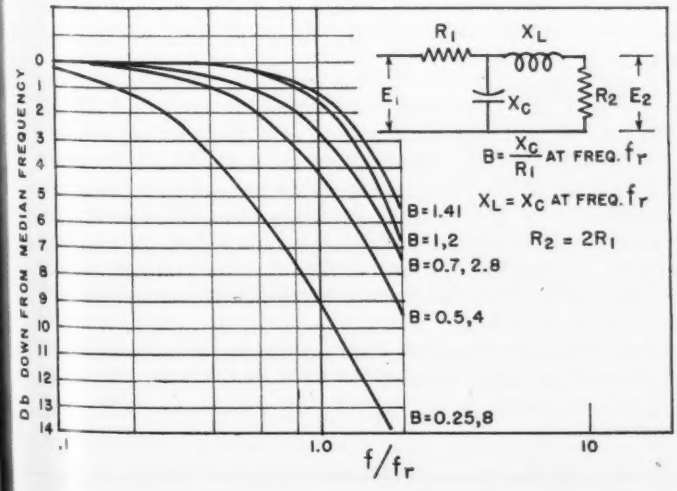
Such a decrease in inductance is brought about partly by a decrease in the number of turns, and partly by a decrease in core size. The latter is possible because of the availability of thin gauge core steel which maintains high permeability and low loss at high frequencies. Winding capacitance is reduced to a small figure by the use of single-layer windings and large spacings between windings. This gives low distributed capacitance in the windings, and low capacitance between windings. The extent to which this is done depends upon the circuit in which the transformer is used.

Matching Requirements

If the transformer is used for line matching, say from 70 ohms to 500 ohms which is the case when a cable is matched to an open wire line, the transformer leakage inductance must be kept very low. In such transformers, the primary and secondary windings are interleaved several times. This increases the winding capacitance, but since the circuit impedance is low, capacitance is not a controlling factor, and the interleaving may be carried out without adverse consequences as far as capacitance is concerned. Such a transformer may be rather complicated to make, because of the large number of interleavings and consequent interlayer connections. But it is physically easier to realize than a high impedance transformer.

High impedance circuits are commonly connected with vacuum tubes. In addition to the requirements of high impedance, vacuum tubes must also work into relatively uniform impedance loads. Otherwise distortion, low output, or excessive plate dissipation result. Variations of the tube load impedance at low and high frequencies expressed in terms similar to the frequency response curves of Figs. 2 and 3 are given in Figs. 4 and 5. Impedance is expressed as a fraction of the load resistance R_2.

Comparison reveals that for impedance uniform to within 10% of



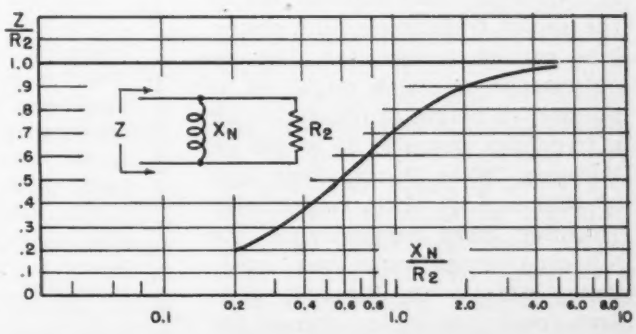
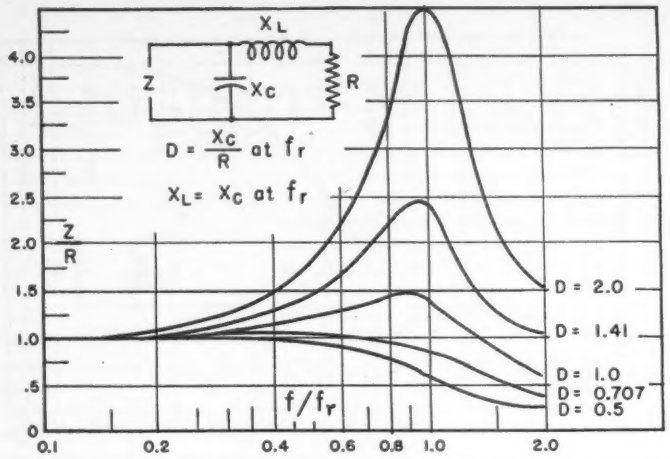


Fig. 3—(left) High frequency response of a stepdown transformer. Fig. 4—(below) Low frequency impedance variations



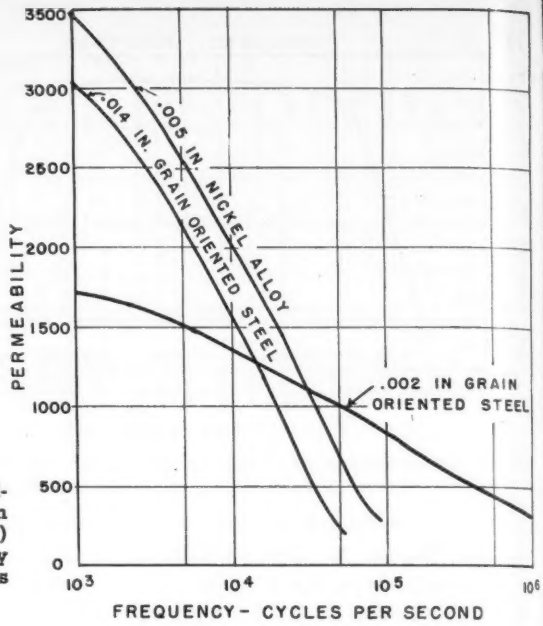


Fig. 5—High frequency impedance curves of a stepdown transformer, and Fig. 6—(right) Variation of core permeability with frequency for typical steels

nominal, the frequency response must be maintained rather flat over a wider range than might be required from the standpoint of frequency response alone in a circuit having linear elements. This modifies somewhat the advantage gained by reducing the uniform response region and making the curves include mainly the incipient and decline frequency ranges.

The smaller the number of turns, the easier it is to realize the necessary OCL without large dimensions. Good core permeability is essential to proper response at high frequencies due to a small coil mean turn. This is true even though the controlling factor at the higher frequencies is not OCL. Fig. 6 shows the advantage gained by decreasing the thickness of steel from 14 to 2 mils at higher frequencies. For comparison, a curve of five mil nickel alloy steel is shown. Close spacing of windings where there is relatively small voltage, and large spacing where there is high voltage, contribute toward reducing leakage inductance without unduly increasing distributed capacitance.

Neither careful design nor the availability of thin gauge high permeability core steel can be regarded as independently responsible for the attainment of high frequency performance, but rather a combination of both. This is illustrated by the output transformer in a power-line carrier transmitter, the requirements of which might be as follows: an output of 100 watts over a frequency range of 50 to 500 kc. Voltages: 700 to 78, step-down with of 4800 and 60 ohms respectively. To meet these requirements, the following transformer was used: Core: .002 in. tk. Hipersil; Core Area (net): 0.45 sq. in.; Turns: 200 to 23 with a leakage inductance of 0.26 millihenry, and capacitance of 50 mmfd (both referred to primary winding). Primary OCL: .050 Henry.

For a triode amplifier the 50 kc performance is governed by $X_N/R_1 = 2\pi \times 50{,}000 \times .050/2400 = 6.5$. From Fig. 2 it can be seen that the response is flat down to 50 kc. Fig. 4 shows that with $Z/R_2 = 3.25$ the impedance is constant within 5% down to 50 kc.

At the higher frequencies, the leakage inductance and winding capacitance resonate at 1400 kc, with $x_c = 2200$ ohms, or $B = 2200/2400 = 0.92$. The highest frequency f is 500 kc, or 36% of the resonant primary and secondary impedances frequency f_r. From Fig. 3 it can be seen that the response is down approximately 0.1 db at 500 kc. Fig. 5 shows that the impedance is nearly constant up to 500 kc.

It is evident that this transformer operates largely in the uniform response region. If 10% be set as a limit of drop in load impedance, then the transformer would be good for operation between 30 and 840 kilocycles. In general, it is more difficult to extend the higher frequency limit than the lower. However, the performance of a transformer depends largely upon the ratio of these two frequencies. Possibilities of increasing this ratio lie mainly in the direction of improved materials, because the limitations of space and incidental effects such as tube capacitance now determine operating bandwidths.

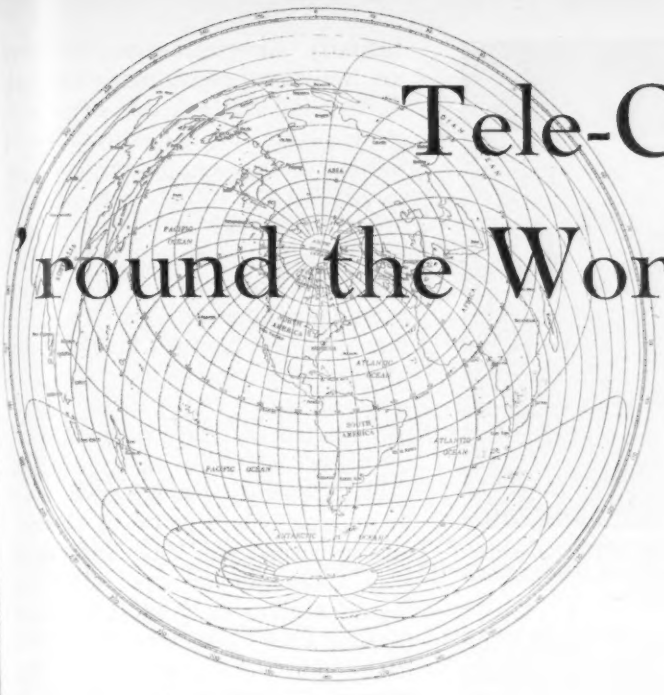
Tele-Tech Sets Record For Radio-Electronic Magazines

• *This first edition of* TELE-TECH *represents in many ways a record of editorial and advertising accomplishment for a first issue of a new publication.*

In number of editorial and advertising pages it outreaches any other first issue of any radio or electronic magazine we know about.

And this publishing record was achieved, as will be recalled, during a period of acute business upset, culminating in the coal strike when many plants were being shut down, postponing or cancelling advertising already ordered. Of the 60 days between the first announcement and the closing of the magazine, one-half of that period was marked by national strikes, actual or imminent. Meanwhile postal service and railroad trains were reduced, delaying deliveries of advertising plates, paper and materials.

Yet, hurdling all these difficulties, here is your 1947 TELE-TECH. *Still holding a record among radio-electronic magazines for first issues, it can be counted upon to grow with the return of stable and normal business conditions.*



Tele-Communications 'round the World

By ROLAND B. DAVIES,
Tele-Tech Washington Bureau

News of engineering matters of importance and of markets in various foreign fields

COLOMBIA BUYING COLLINS BC TRANSMITTERS—A new broadcasting company, the *Radiodifusora Interamericana Limitada,* has just been organized at Bogota, Colombia, and will broadcast on the frequencies 850, 6,000 and 9,250 kc. The Collins Radio Co. (Cedar Rapids, Ia.) is supplying the transmitters, which are expected to be in operation by March, 1947. A modern building is being constructed in the center of Bogota to house the studios, a radio theater and the administrative offices. The total cost of the station is estimated at $300,000.

PANAMA HAS MOST POWERFUL C.A. BC Stations — Panama last Fall inaugurated the most powerful radio station, HOX, on the Isthmus, with 7.5 kw, which is 7½ times more powerful than any other station on the Isthmus. It is planned to have transmitters for three short-wave stations having 7.5 kw power, an FM station to be used as a radio link between the transmitters and its future downtown studios. The long-wave station is having its power increased from 300 watts to 1 kw as soon as an RCA transmitter is received.

JAMAICA'S SHORTAGE OF LOW-PRICED HOME RECEIVERS—Jamaica is being pointed out as a possible market for low-priced home radio receivers and American manufacturers might canvass the situation. Previously, English firms held this market closely, but the high prices of their sets have kept them out of the reach of all but the wealthier people. It is estimated that there are about 12,000 receivers in Jamaica although only 8,000 have been registered and have paid their license fees. But the government-owned broadcasting station has been operating only two hours daily so, until the idea of a commercial broadcasting station has been "got over" to the colony's governmental officials, U. S. manufacturers should sell their sets with short-wave reception from the United States and contiguous Latin American countries as the chief attraction.

PORTUGAL WILL LINK UP COLONIES — The Portuguese Government has arranged for equipment for radiocommunications by telephone and telegraph between that country and its colonial possessions in Timor, India, Africa and China, the first link in the new system being on the island of Timor where all outside communications services were destroyed during the war. The island is now isolated except for radio service provided by a Portuguese warship lying off the coast.

NEW ZEALAND PLANS SIXTEEN NEW BC STATIONS—Construction of 16 new broadcasting stations in New Zealand including one of 60 kw power, is to be performed by the Amalgamated Wireless of Australasia, Ltd. The 60 kw station has about six times the power capacity of any standard broadcasting outlet in Australia.

HAVANA SEES FIRST TELEVISION—The people of Cuba were given their first look at television in action during a thirteen-day demonstration at Havana in December. A large gathering of government officials and press representatives saw the opening broadcast—a spirited jai alai game, one of the national sports of Latin America. Bullfights, horse-racing, drama and gala musicals were later shown on the television screen under the auspices of the *Compania Importadora de Lubricantes, S. A.* which is installing a modern television station, completely Du Mont equipped, in Havana, to be ready by July.

IRAQ, BRAZIL, CHINA, TO BRITISH MARCONI — British Marconi recently secured following contracts for telecommunications and broadcasting installations: One installation to cost around 35,000 pounds and including short-wave and medium-wave transmitters will be for Iraq. Two contracts were secured from Brazil—a 20-kw medium-wave broadcasting transmitter, two 25-kw shortwave transmitters and FM VHF links for a new broadcasting station of the *Jornal do Commercio* at Recife; and

the other for *Sociedad da Bahia,* where a 20 kw transmitter is to be supplied for both medium-wave and short-wave broadcasting operations. The Chinese Government has also ordered four transmitters for radiotelegraph and radiotelephone.

BOLIVIA TO EXPAND RADIOTELEGRAPH SYSTEM — Bolivia looms as a fertile field for U. S. radiotelegraph equipment. A new government budget for improvement and expansion of radiotelegraph service, totalling 4 million soles (approximately 6.5 soles per U. S. dollar), is being formulated for approval by the Bolivian Congress.

LATIN AMERICA PLANS COMMERCIAL TELEVISION—Television broadcast service for Latin America is being considered by leaders of the radio broadcasting industry in Mexico, Cuba, Puerto Rico, Brazil, Argentina, and Chile as a sequel to RCA's first demonstration of modern television "south of the border," it has been reported by Meade Brunet, Managing Director of the RCA International Division. Bullfights were televised at the Plaza Mexico, new 60,000-seat bullring in Mexico City, and the program was transmitted by microwave radio relay to the Hotel del Prado, six miles away, where 7,500 spectators viewed the event on the screens of RCA Victor television receivers.

RADIO EXPORTERS AIDED BY COMMERCE DEP'T—The U.S. Commerce Department is now geared to aid radio and communications manufacturing companies in their export planning through a newly-strengthened Telecommunications Section in the Office of International Trade. This organization, which is headed by E. C. Shaffer, formerly with American Telephone & Telegraph and Westinghouse for a number of years and wartime chief of the Communications Division of the former Foreign Economic Administration, has been set up to handle inquiries on general phases of export trade or specific questions regarding export conditions, facilities and trade opportunities. Shaffer's section is a part of the Transportation and Communications Division of the Commerce

E. C. Shaffer, new head of Telecommunications Section in Office of International Trade, Dept. of Commerce

Department, which is headed by Serge G. Koushnareff, a naturalized Russian and graduate of the University of Moscow and Columbia.

With the British radio manufacturing companies and Philips of Holland invading many foreign fields with their products, particularly in Latin America and the Far East, and Sweden's Ericsson company forging ahead in telephone equipment for Latin America, particularly, American manufacturers are hopeful of resuming rather full-fledged export marketing next year. During 1946, strikes, shortages of materials and manpower were realized by the Commerce Department authorities in statements to *TELE-TECH* to have been major factors in retarding U. S. radiocommunications exports.

In 1947 the prospect is that table model radio receivers particularly will be a major export item. American manufacturers, Commerce Department officials declared, had been frequently handicapped even in making bids because of the domestic situation. This has been true especially in the telephone manufacturing field in the United States since our manufacturers have felt it a primary duty to serve the needs of American users.

The new Telecommunications Section of the Commerce Department is preparing analyses of broadcasting and communications situations in different countries. The first publication, to appear about Feb. 1, will be a compilation of commercial broadcasting stations in the Philippines.

Paper Tape Magnetic Recorder

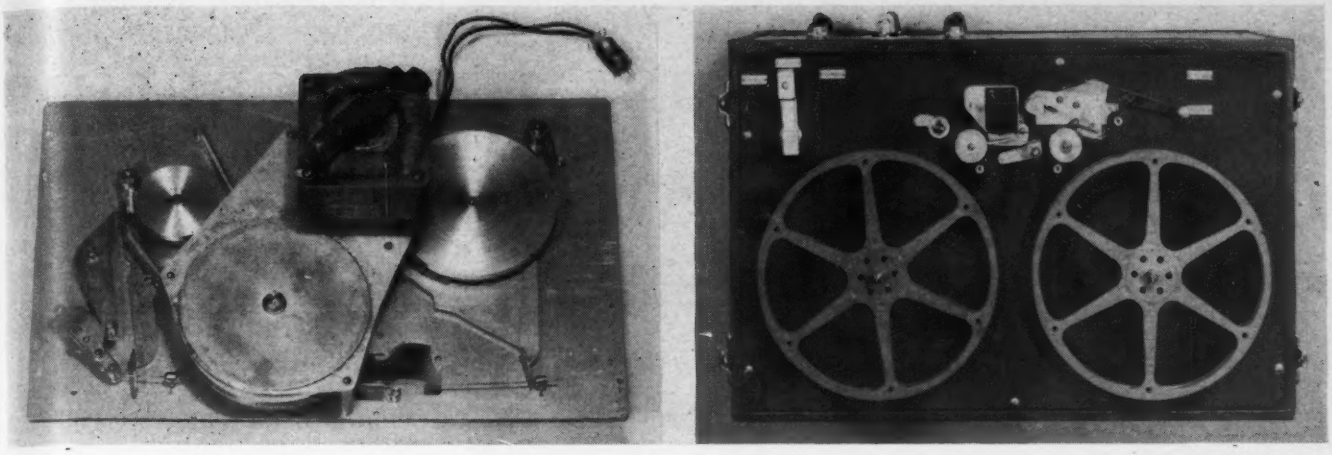
• Expanding the number of different types of recorders currently available, a new paper tape for sound recording in which the material receiving the magnetic impressions is a metallic base powder painted on the tape, rather than an oxide, has been developed. It permits recording at a fairly slow tape speed as its magnetic properties approach those of Alnico III (see Table I). The development is due to Hugh A. Howell, Research Engineer for The Indiana Steel Products Co.* and has been incorporated into commercial recorders for use with home radios or separate amplifiers.

Hugh A. Powell, research engineer for Indiana, demonstrates drawer recorder

Christened Hyflux, the magnetic properties of the tape material apparently are due to the process of its preparation as much as to its composition. Its high coercive force requires a considerably different technic for recording and erasing however, than that used with wire and lower coercive force materials. The net result is a simpler recording mechanism and more assured permanency of the tape.

The recording advantages of Hyflux tape are attained by coordinating its inherent magnetic capacity with the specially designed recording head and associated circuits which utilize its high coercive force

*6 No. Michigan Ave., Chicago, Ill.



Left—Bottom view of driving mechanism of magnetic tape recorder, adaptable to both portable and drawer models. Right—Top view of recorder with cover removed to reveal details of the recording and erasing heads, tape in playing position

to maintain a high signal-to-noise ratio. By using higher tape speeds, very high fidelity can be reached at extreme frequencies which would include the third harmonics. This, however, is not considered the normal operational range because of the sacrifice in recording time entailed. The frequencies generally used for music are from 100 to 5,000 cycles.

At this time, Hyflux will operate satisfactorily for most recording purposes at frequencies up to 6,000 cycles with a tape speed of 8 in. per second. While further development may permit a wider frequency range or lower tape speed, this is considered adequate for home and commercial needs.

The advantages of using a paper tape are numerous. It can be reeled more easily, can be mended with scotch tape and easily edited, can be marked with pencil on the paper side for reference purposes and is just as strong as fine wire. In addition the paper provides space separation between magnetic impressions on adjacent turns on the reel. This is claimed to reduce cross magnetization during extended storage.

New Recorder Design

Due to its high coercive force Hyflux could not be used efficiently in existing tape recorders. Hence a new recorder has been built for its use in a flat or "drawer" model to go under a table radio. This utilizes the radio's amplifier directly or includes first a simple low gain preamplification. A half hour program can be recorded on a 7 in. standard 8 mm film reel.

The technical specifications of Hyflux tape are: Composition—metallic powder coated on paper tape; tape dimensions—width ¼ in.; thickness—0.002 in. (including coating thickness of 0.0005 in.); break load of tape—6 lb.; excellent dimensional stability due to choice of paper base; superior to any plastic ribbon available at this time.

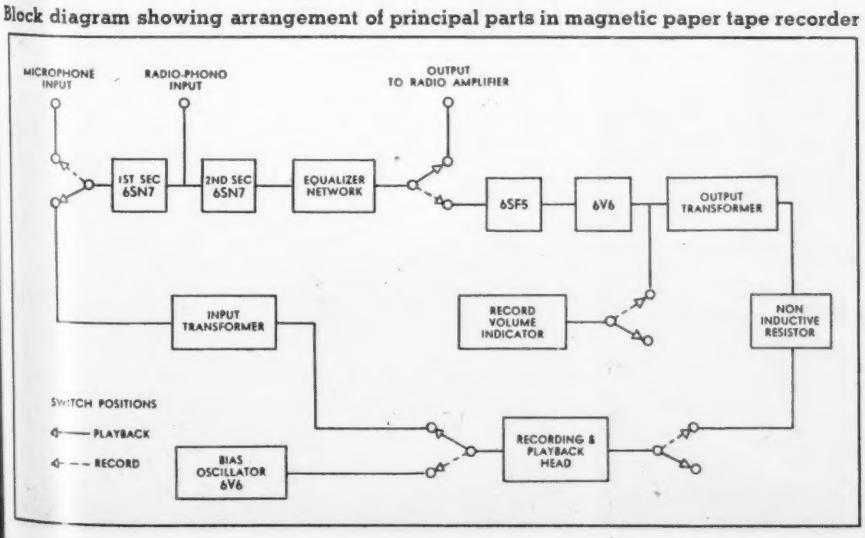
A comparison of the magnetic properties of Hyflux with other materials is shown below:

TABLE I

Material	Hp	Bp	Br	Energy Product Bd Hd Hc Max/106		Sp Gr
Vectalite (sintered oxide)	3000	4800	1600	900	0.5	2.77
Magnetite	3000	3650	1600	190	0.09	2.62
Hyflux	3000	9800	4450	435	0.71	4.0
	3000	11000	5000	500	0.85	4.8
Alnico III	2000	12000	6900	475	1.35	6.9

It should be understood that any of the above materials, if suspended in a finely divided state, would exhibit much lower values of Br and in all cases the value of Hc would remain the same or perhaps slightly higher.

Block diagram showing arrangement of principal parts in magnetic paper tape recorder



See Police Utilization of Facsimile Equipment

Vernon Watson of Oak Park, Chicago, representing a police organization that has long pioneered in radio, expresses the opinion that facsimile will find an important place in police radio in the near future. One chief advantage of the tape facsimile recorder is that it eliminates the human error that may arise due to loss of memory of the spoken order. The tape record is received over the squad car facsimile system as a printed order and can be posted for repeated reference or can be used as a source of authority.

The newspaper type facsimile provides a very important advantage that is so necessary in police work. This is the transmission of a photograph to the squad car for identification purposes.

United Nations Broadcasting and Sound System

Technical details of facilities at Flushing Meadows and Lake Success for public address and for use of AM, FM and television broadcasters

• Approximately 400 amplifiers, 300 loudspeakers and 200 microphones interconnected with over fifty miles of paired audio cable indicates the magnitude of the United Nations sound broadcasting installation. Beginning with the assurance that the most important organization in the world today is worthy of the best in technical perfection, the installation of all acoustical and broadcast facilities at UN meeting centers has been made with a persistent goal representing the finest technical performance.

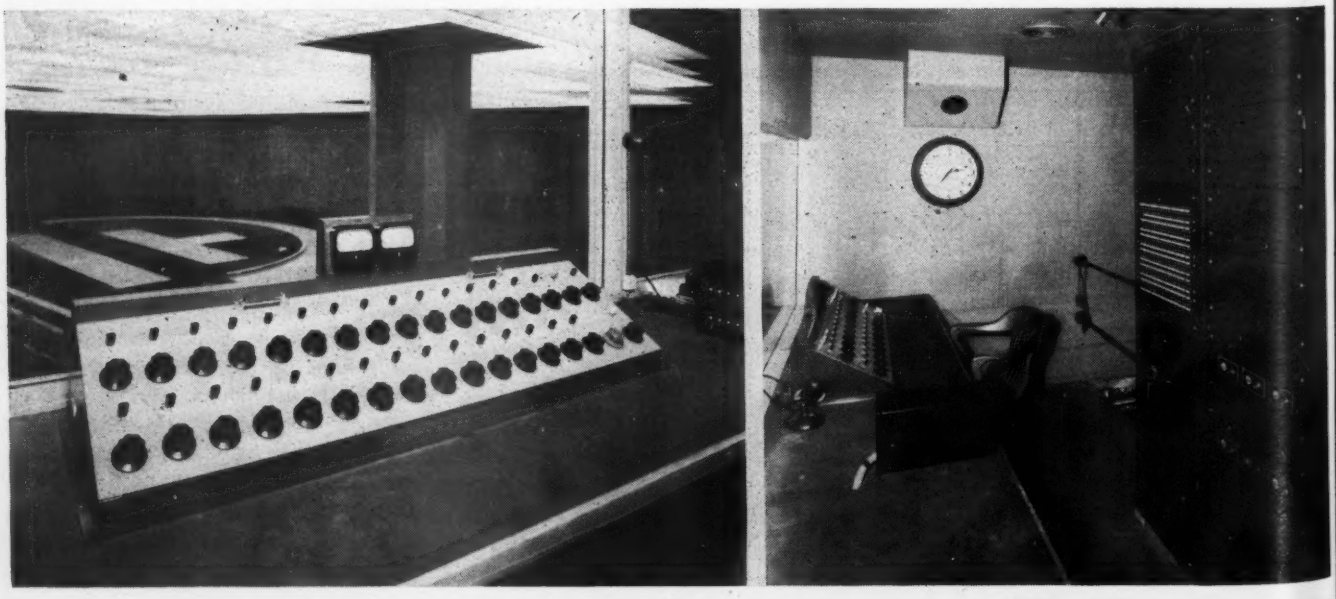
The sound systems of the General Assembly Hall at Flushing Meadows and the meeting centers at Lake Success on Long Island incorporate the latest design and installation technics and combine recent acoustical and electrical advances to satisfy a set of specifications intended to attain an overall system quality that lies well within the rigid FCC requirements for FM broadcasting. This precaution was taken so that any future need for radio broadcasting of UN activities on the FM band will not find the equipment inadequate.

All of the open proceedings of the United Nations from any of the meeting centers is available to radio broadcasters, television broadcasters, film newsreels, the news services, recorders and to all of the international broadcasting stations. In addition to these services, the UN meeting centers are equipped with sound reinforcement systems to facilitate local UN proceedings.

Prior to the acoustical construction at the various meeting centers, it was recognized that the main problem was to reduce reverberation time at low frequencies without affecting high frequencies. Accounting for seating capacity and the nature of the upholstery, the treatment applied to the walls was designed to absorb the lower tones at the same time reflecting the higher ones. The side walls of the auditorium were splayed in order to eliminate standing waves, thus reducing resonances especially at the lower frequencies. The rooms were heavily carpted and this served the dual purpose of acoustical treatment as well as furnishing. The ceilings were processed with standard acoustical perforated tiling. Part of the wall areas were lined with mahogany or oak plywood and slanted. In this way good acoustical treatment was obtained, at the same time enhancing structural beauty.

The General Assembly Hall is situated in the New York City Build-

(Left) Control booth of the Economic and Social Council showing the control console and operator's view of the chamber. (Right) Security Council control booth showing the placement of two equipment racks. Note intercom box in foreground



ing at Flushing Meadows, and is equipped with a public address system and broadcast facilities using RCA equipment. All delegate speakers address the delegates as a body from the rostrum. Two multi-cellular high fidelity loudspeakers are used to broadcast sound over the main floor area and a third unit serves the balcony which is reserved for the press. In addition to these multi-cellular units, dynamic loudspeakers are installed in the ceiling beneath the balcony and the broadcast and television booths on each side of the auditorium to insure adequate sound coverage for these remote areas.

The United Nations broadcast facilities at Lake Success constitute a larger part of the total installed sound equipment. The meeting centers at Lake Success consist of two council chambers, one for the Security Council and the other for the Economic and Social Council, and four large conference rooms for meetings of the various UN committees. Each of the council chambers and conference rooms is equipped with an individual sound and broadcast system.

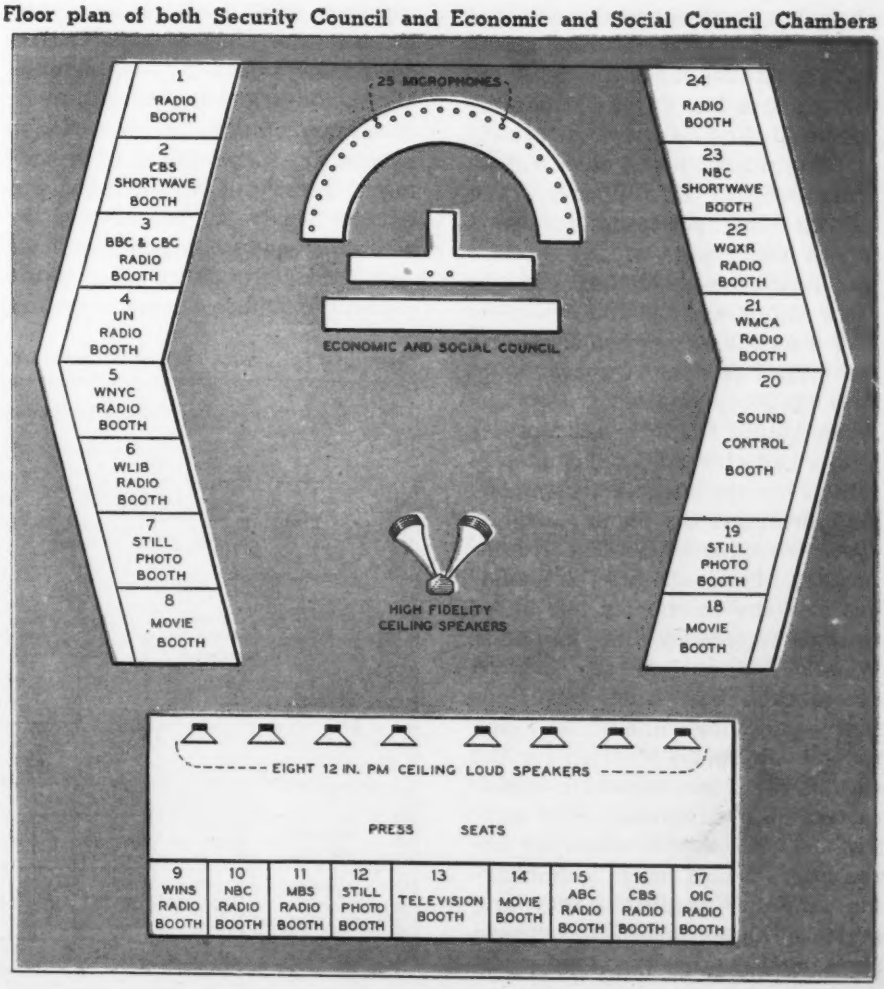
NBC broadcasting and television personnel alerted for the arrival of UN dignitaries for second session of the first General Assembly at Flushing Meadows on Long Island

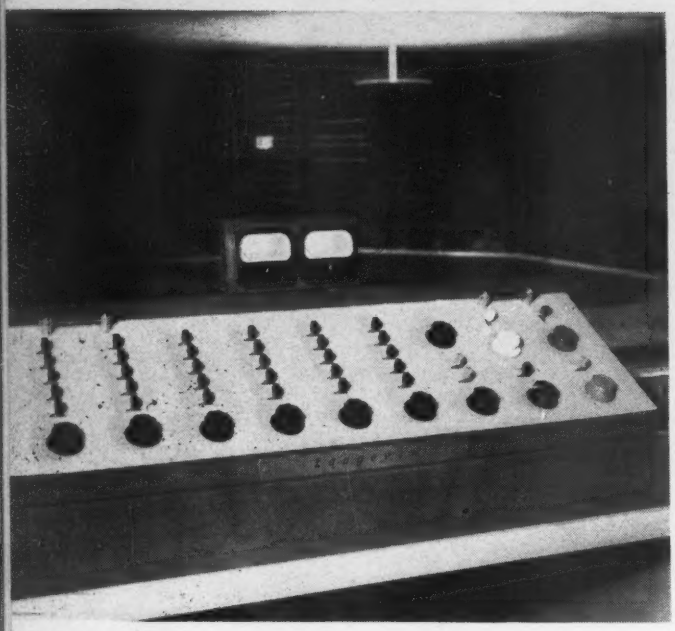
Sound Problems

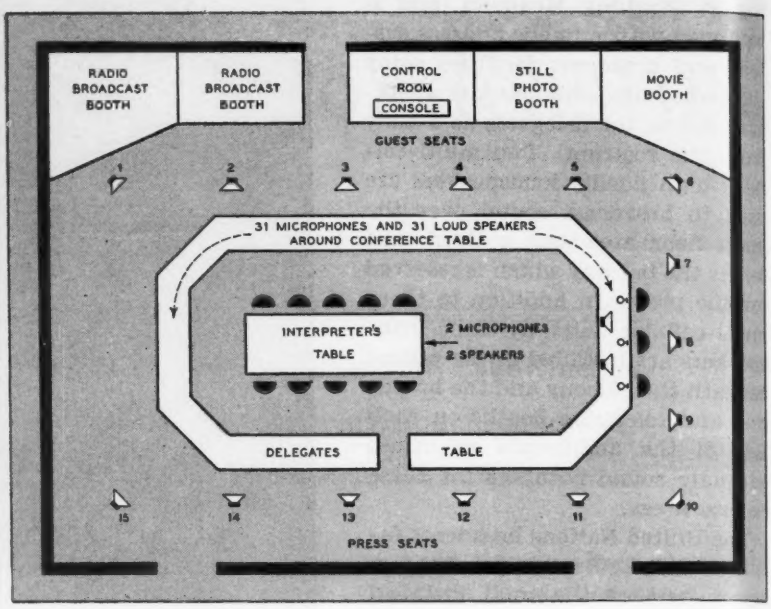
All six sound systems are fundamentally the same except for the loudspeaker arrangement between the conference rooms and the council chambers. In the conference rooms, the microphones and speaker units are equally spaced around a large oval table approximately 50 ft. long. The size of the conference tables and the nature of the discussions require that individual loudspeakers be mounted in the conference tables and interspersed between the microphones. When any particular delegate is speaking, the built-in dynamic speakers on each side of his open microphone are automatically cut off. Operational practice verifies that feedback problems are thus eliminated.

Since all of the sound systems in the six meeting centers are essentially alike, a description of the operation of one is adequate for an understanding of all. In the simplified block diagram illustrating the conference room sound system, the symbol M designates microphones and the number in each block is the total number used. Each microphone feeds into its own individual pre-mixing amplifier designated as PMA. These amplifiers are located in a rack in the control booth overlooking the conference room. The output feeds to a key in the control console which serves to turn the microphone on or off as well as to operate relays which cut out the two speakers adjacent to the open microphone.

Floor plan of both Security Council and Economic and Social Council Chambers







(Left) Control console of conference room No. 1 showing the switch and gain control arrangement. Note conference table. (Right) A typical floor plan for four conference rooms showing the loudspeaker, microphone and service booth locations

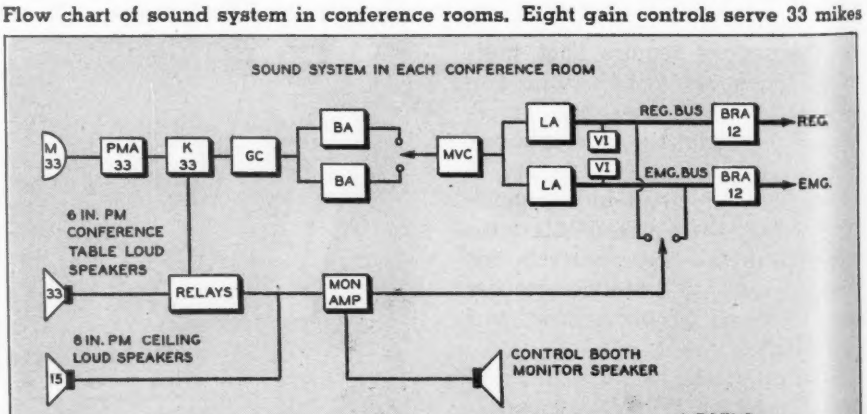
The output from the control console key feeds into a bank of gain controls shown in the block diagram as VC. The number in the block VC is 8. This indicates that a total of eight gain controls are all that are used with the thirty-three microphones. The chairman's microphone has its own gain control, and the two interpreters' microphones are both fed into control No. 2. The remaining six gain controls serve all thirty delegate microphones, each control handling five microphones. The outputs of all gain controls are then fed to the inputs of two booster amplifiers, one a regular and the other an emergency, and both feed into a switching key which selects the output of either the regular or the emergency amplifier.

The output from this selector key is directed through a master gain control on the console to two line amplifiers, one the regular and the other the emergency. The regular line amplifier feeds into the regular bus and the emergency bus is fed by the emergency line amplifier. Console VU meters are bridged across each bus. Each bus feeds twelve bridging amplifiers which provide UN sound program for the various radio and television broadcasters, film newsreels, news services, etc. The output from the line amplifiers is also fed to a monitoring amplifier through a key and provides audio power for fifteen permanent magnet type loudspeakers mounted in the ceiling for general coverage of the areas away from the conference table. A monitoring speaker is provided in the control booth and fed from the monitoring amplifier.

The sound system in each of the three other conference rooms is identical with that described here. The Security Council has a conference table equipped with eighteen microphones, and the Economic and Social Council table is equipped with twenty-five microphones to provide for a larger number of delegates. Greater flexibility is obtained by providing each microphone with its own gain control. In each of the council chamber sound systems, forty-eight bridging amplifiers are used instead of twenty-four as in the conference rooms, in order to provide increased facilities for the various news media, for the principal reason that the proceedings in the council chambers are generally of greater importance and therefore have higher news value. Each chamber is equipped with two high fidelity multicellular loudspeakers comprising high frequency horns and low frequency dynamic units, directed so that all feedback is eliminated, A number of dynamic loudspeaker units are installed at the backs of the chambers to reinforce the sound to the press areas.

Each council chamber has twenty-

Flow chart of sound system in conference rooms. Eight gain controls serve 33 mikes

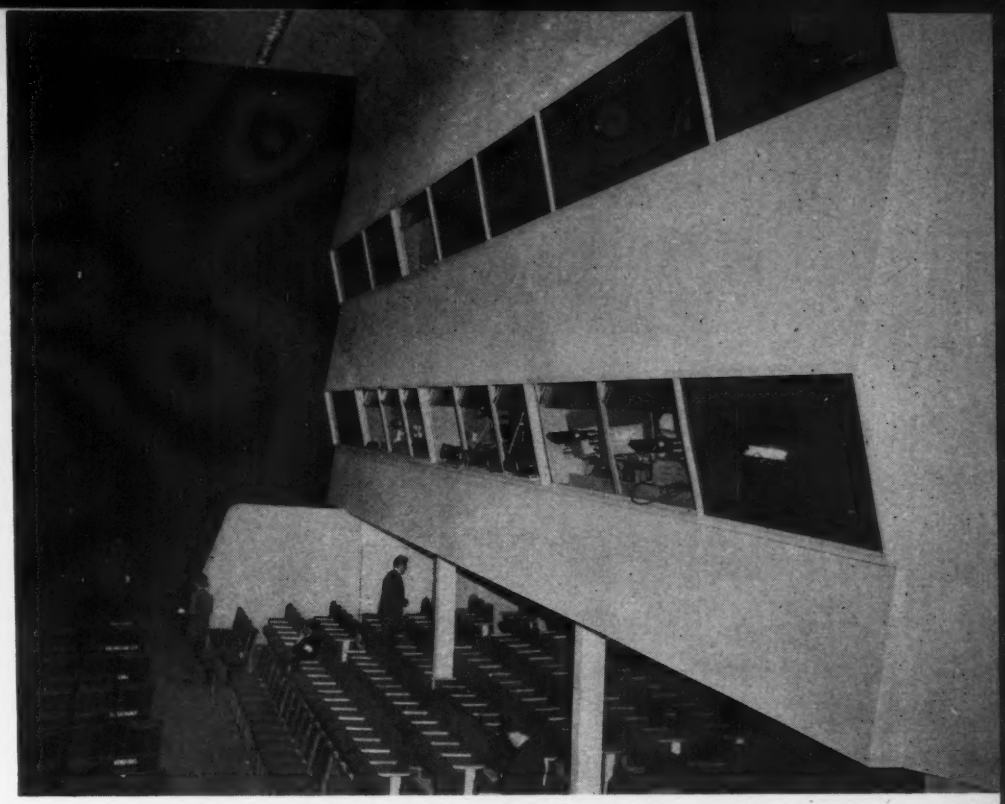


	M	PMA	K	GC	BA	K	MVC	LA	BRA
SECURITY COUNCIL	20	20	20	20	2	1	1	2	48
ECONOMIC AND SOCIAL COUNCIL	30	30	30	30	2	1	1	2	48

—LEGEND—
M - MICROPHONES
PMA - PRE-MIXING AMPLIFIERS
K - KEY SWITCHES
BA - BOOSTER AMPLIFIERS
MVC - MAIN VOLUME CONTROLS
LA - LINE AMPLIFIERS
VI - VOLUME INDICATORS
BRA - BRIDGING AMPLIFIERS
GC - GAIN CONTROLS

four booths: twelve for radio broadcasting, one for television broadcasting, five for still photographers, three for motion picture companies, two for special radio features and the main UN monitoring control booth. Each conference room has five booths: two for radio control, one for film newsreels, one for still photographs and the main UN monitoring control booth.

All eight sound systems, two at Flushing Meadow and six at Lake Success, can be interconnected to broadcast the proceedings from any hall or conference room to all other UN assemblies. This flexibility enables any speaker, such as the Secretary General, to address all UN delegates when necessary.



A view illustrating the double-layer construction of the newsreel, still camera, television and sound broadcasting booths at the United Nations General Assembly Hall

Multi-lingual Monitors

It is imperative for the monitoring operators in the control booths to maintain constant vigil for cues in order to anticipate sudden actions of the delegates. The inherent complication of the multi-language discussions denies the operator any indication from the spoken word so heavily relied on in radio broadcast service. His only recourse is alert observation of the delegates for signs such as the removal of reading spectacles, pushing away the microphone, etc.

One interesting case occurred in connection with the delegate from the Soviet Union. When Gromyko concluded an address, the control operator cut the U.S.S.R. microphone and turned on the interpreter's circuit for the Russian-to-English translation. During the course of the translation, the Soviet delegate, objecting to the interpretation of a passage, interrupted the interpreter to make the correction into a dead microphone. Quick action on the part of the operator, however, caught all of Gromyko's correcting words except possibly the first one or two. It was apparent that the operator's swift response to such an irregularity was due to his knowledge of the Soviet delegate's habits and mannerisms. In addition to operational knowledge of the sound system, therefore, UN control operators are charged with the added responsibility of knowing the microphone technics of the various delegates.

Recognizing the importance of the sound broadcast system in expediting UN proceedings, all committee chairmen render complete cooperation with control booth operators by pointing to the next speaker as well as by naming him.

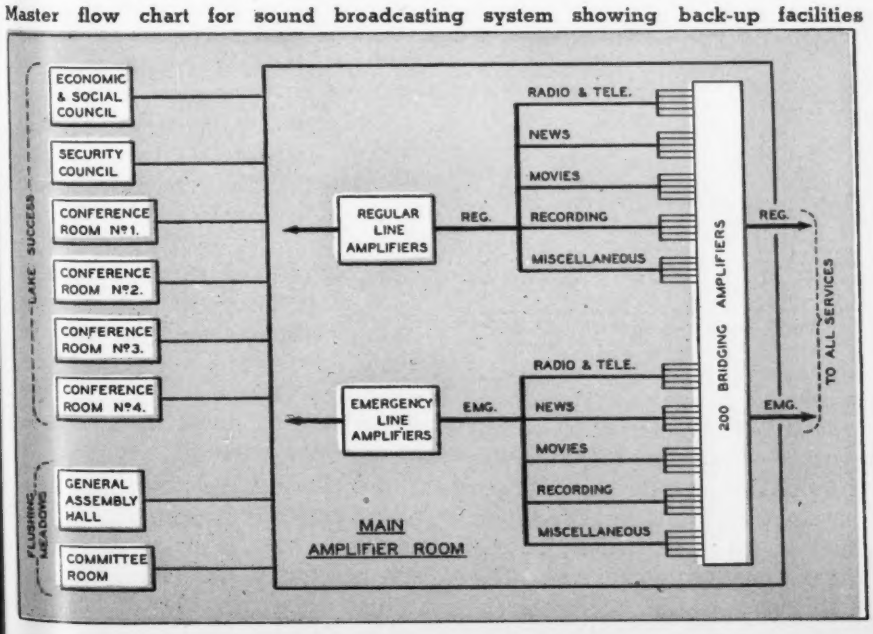
As a further aid to the control room operator, all consoles are faced with a translucent plastic sheet on which delegates' names are crayon written under corresponding microphone keys. Changes in seating arrangements are a common practice at UN conferences, and names are erased and written in by hand to conform to the changes. In this way the operator, hearing the chairman designate the next speaker, can tie up the name with the proper microphone switch immediately.

Edward J. Content, acoustical consultant of Stamford, Conn., was retained by the architectural firm of Voorhees, Walker, Foley and Smith to draw up the sound broadcast specifications and to supervise equipment installation. The amplifiers were designed and manufactured by the Langevin Co., New York.

Of particular interest is the Langevin bridging amplifier Model

(*Continued on page* 154)

Master flow chart for sound broadcasting system showing back-up facilities



Survey of Wide Reading

Electronic news in the world's press. Review of engineering, scientific and industrial journals, here and abroad

Electromagnetic Energy Distribution in Front of Apertures and Reflectors

H. Born (Hochfrequenztechnik und Elektroakustik, Berlin, Vol. 62, July issue, pp. 20 to 23)

A formula for the distribution of acoustical energy in front of an oscillating surface appears to be applicable to electromagnetic radiation, both being due to interference. Results of experiments reported in previous literature are compared with the formula obtained and satisfactory agreement is reached.

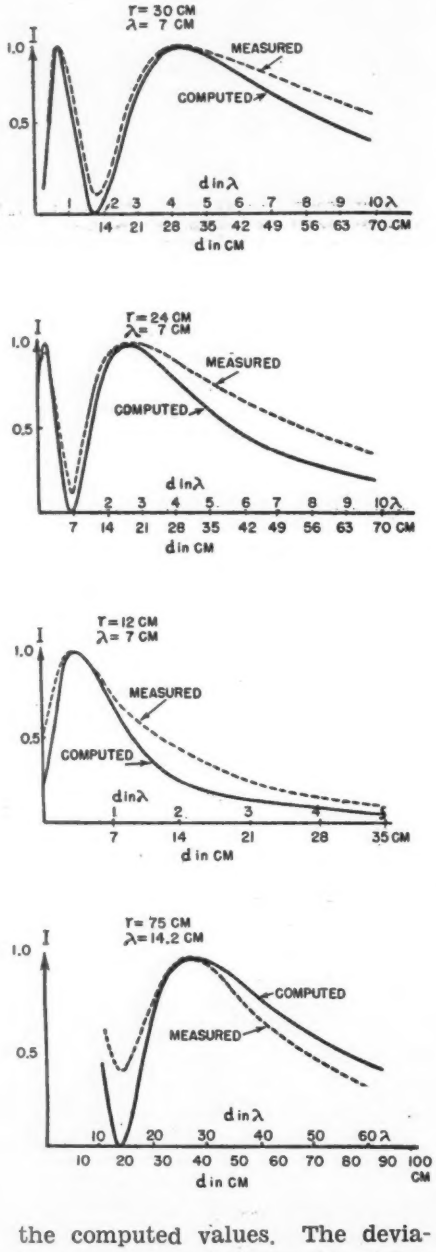
The intensity, I, of an acoustical radiation along the line normal to the center of a circular radiator is given by:

$$I = \sin^2 \pi(\sqrt{r^2 + d^2} - d)/\lambda,$$

where r is the radius of the radiator, which is assumed to be excited at equal phase and amplitude on its entire surface, and d is the distance of the point at which the intensity I is measured from the center of the radiator.

According to this formula, the energy density, I, oscillates along the line normal to the radiator between zero and unity, the distances between the maxima and minima diminishing as the radiator is approached.

The dashed lines in the figure represent measured energy intensities reported in the literature of electromagnetic radiation emitted by a dipole mounted at the focal point of a parabolic reflector; a circular diaphragm aperture is mounted in front of the dipole and the distance, d, is measured from the center of this aperture. For the first three diagrams the wavelength, λ, was 7 cm, and the radius of the aperture, r = 30 cm, 24 cm, and 12 cm, respectively. The full lines indicate



the computed values. The deviations, particularly noticeable at low intensity points, are attributed to the finite area of the receiver in the experiment, while the computation relates to a point intensity at the normal line to the radiator. The fourth curve was plotted from observations where the electromagnetic field in the aperture was not known to be uniform due to a close spacing between the parabolic reflector and the diaphragm aperture.

The formula is adapted for dissipative propagation media and comparison with measured values establishes fairly good agreement in this case also.

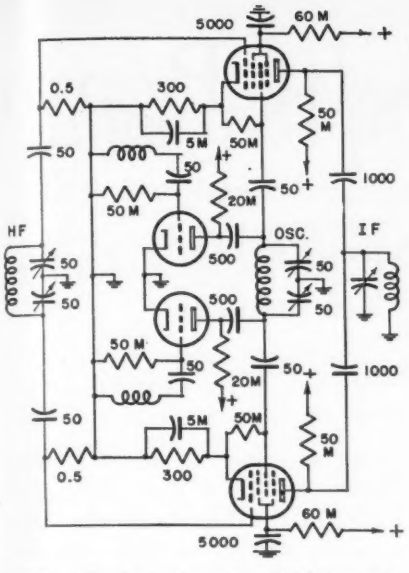
1,000 Line Television Receivers

R. Aschen (La Television Francaise, Paris, No. 16, August 1946, pp. 2 to 4, No. 17, September 1946, pp. 3 and 4)

Details are given relating to the design of television receivers based on 1,000 line scanning. An EF50 operating as mixer for a 300 mc wave, with a separate oscillator, gives a conversion amplification of 150 and a conversion transconductance of 1.5mA/V assuming a plate impedance of 100,000 ohms and an intermediate frequency of 1 mc. A secondary emission tube would give a transconductance of 5mA/V at 300 mc, but the noise voltage would exceed that of the high frequency stage by a factor of 3 or 4.

A considerable improvement has been obtained with a twin-pentode, connected in a push-pull circuit. In a conventional single ended circuit the input resistance in the neighborhood of 43 mc would be 6,000 ohms for the EF50, but in the push-pull arrangement it may be made 50,000. The theoretical amplification factor is then 7 per stage, but only about 2.5 is realized in an actual circuit.

With a twin secondary emission tube connected in push-pull, actual amplification factors of 20 can be attained for 300 mc waves. Another similar tube amplifies a 300 mc



Push-pull mixer stage for 1000-line television receiver

wave 40 times, a 600 mc wave 10 times and a 1200 mc wave 5 times (assuming the following stage to have the same input impedance).

In a diode detector circuit, for a band width of 9 mc and a circuit capacitance of 20 $\mu\mu f$ in parallel to the diode, a value of 900 ohms for the diode load is arrived at. In the case of a EA5 diode used for 1,000 lines, the ratio of the rectified voltage to the intermediate frequency voltage amplitude is equal to 0.58, compared with 0.35 for a 6H6.

Piezoelectricity of Sugar Sodium-Halogens

B. Matthias and W. Merz (Helvetica Physica Acta, Basel, Switzerland, Vol. 19, No. 4, July 31, 1946, pp. 229 and 230)

Artificial crystals consisting of a combination of two parts dextrose and one part sodium-halogen—having the same crystalline structure as quartz—were investigated as to their piezoelectric properties. The resonance frequency as a function of temperature was measured for three series of plates cut at different angles and the temperature coefficient derived. The temperature coefficient proved to be positive, average value 180×10^{-6}, and varied considerably for different cuts. Similar to quartz, the artificial crystals are highly suitable for thickness vibrations; frequency range covered and quality are equal to those of quartz. Although the temperature coefficient cannot, as yet, be reduced to zero, synthetic crystals may be used in the megacycle range.

Harmonic Analysis with Phasing Circuit

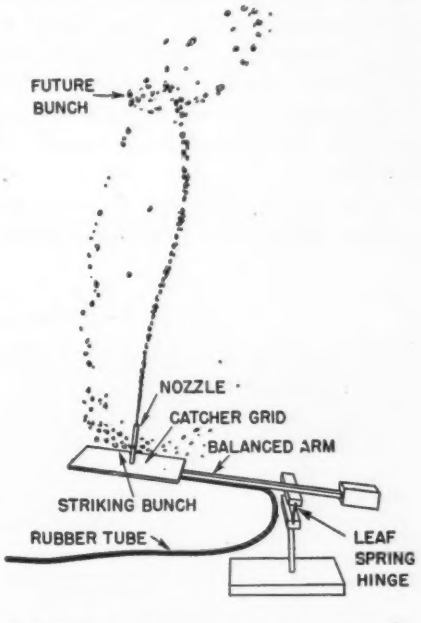
A. Colombani (Compte Rendus, Paris, October 8, 1945, pp. 399 to 401)

By connecting an impedance bridge across the output resistor of a low-capacitance pentode a voltage is obtained the phase shift and amplitude of which may be independently controlled. A method of harmonic analysis based on this circuit and an oscillograph is described.

Water-Jet Analogue of the Reflex Klystron

W. J. Scott (Proceedings of the Physical Society, London, Vol. 58, Pt. 4, pp. 475 and 476)

A water-jet analogue demonstrating operation of the reflex Klystron was constructed. Assuming the balanced horizontal arm to be oscillating, the velocity of the water will be modulated upon passage through



Water-jet analogue of reflex Klystron

the moving nozzle. Similar to the electron bunching action in a Klystron, the water accelerated during the second half of the upward stroke will catch up with the water retarded at the first half of the following downward stroke to form a bunch. If jet velocity and resonant frequency of the balanced arm are suitably dimensioned, the falling water bunches will hit the gauze catcher grid just when the balanced arm is moving downwards, thereby increasing its velocity. Oscillations can be maintained by flight times corresponding to approximately 1¼, 2¼, 3¼, etc., cycles. The slight increase or decrease of oscillating frequency, caused by slightly lowering or increasing the jet velocity, and consequently the flight time, corresponds to the electronic tuning of the reflex Klystron.

Electromagnetic Field of Airplane Antennas

A. Poirot (Annales de Physique, Paris, September, October 1945, pp. 546 to 555)

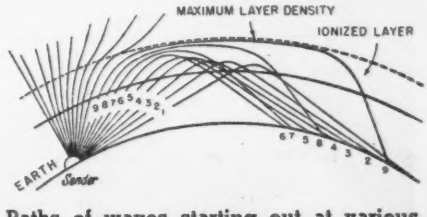
The directional characteristics of the electromagnetic field emitted by a short-wave transmitter mounted on an airplane are influenced by the presence of the airplane. These effects are the object of the investigation which reveals the importance of objects in the vicinity of the transmitter and receiver antennas. For the purpose of the investigation, a small airplane model was mounted on a supporting structure which proved to be of influence on the radiation pattern. Detailed studies of various materials used for the interfering object, situated at different positions with respect to transmitter and receiver, are reported.

Ionosphere and Wave Propagation

F. Vilbig, VDE (Elektrotechnische Zeitschrift, Berlin, December 1944, pp. 413 to 419)

Conditions for the propagation of electromagnetic waves are studied and the effects of the various ionized layers, making up the ionosphere, on different wavelengths are discussed.

The shorter the wavelength of a wave, the greater the depth of penetration into the ionized layer; waves of sufficiently high frequency traverse the layer. Assuming right angle incident of the wave, the



Paths of waves starting out at various angles under the influence of an ionized layer

highest frequency, f, to be reflected from a layer of maximum ion concentration, C_{max}, per cm³, is given by:

$$C_{max} = f^2 \pi m / e^2,$$

where m and e are the mass and

(*Continued on page* 160)

TV on Modulated Light-Beam

DuMont engineers transmit video signals by modulating cathode ray in tube having new phosphor with rapid delay characteristics

• The disclosure by DuMont researchers of components which make practical the use of a light beam as a medium for the transmission of television pictures, has introduced a new topic for discussion among communication engineers. Although radiation in the visible spectrum has been the one and only means for direct vision, but little progress has been made in using light to send the rapid sequence of one-at-a-time signals necessary for scanned viewing.

Light beam communication has made remarkable progress from the early blinker signals through war developments, so that voice communication channels can be established using several modulation methods. The problem has been largely that of either providing a light source that is modulated inherently, or a means for modulating a regular light beam by some external means.

A somewhat different solution to the problem of high frequency modulation was disclosed recently by Dr. T. T. Goldsmith and associates in the DuMont Laboratories. The system uses a specially constructed cathode ray tube as the light source. No loss of picture fidelity or contrast was noted with a 4.5 mc video signal range. This modulating tube (Fig. 1) features a gun with superior modulation characteristics adapted for high beam current, and a special phosphor that has essentially no phosphorescence delay. The beam in this tube is not deflected. The system that was demonstrated at the Washington, D. C., section of the A.I.E.E. November 27, is shown in Fig. 2.

The phosphor used in the tube shown in Fig. 3, is one of a new series of materials under development. It has a dull, light-green color, with a delay time less than a tenth that of calcium tungstate (P_5) the hitherto fastest standard phosphor. The screen has, incidentally, an efficiency approximately 60% of that of the highly-brilliant (P_1) phosphor. The new phosphor is still experimental and will not be given a standard designation until tests are continued to determine whether even higher speeds and greater brilliance can be obtained.

In the demonstration, pictures were sent only a short distance, although the signal level received

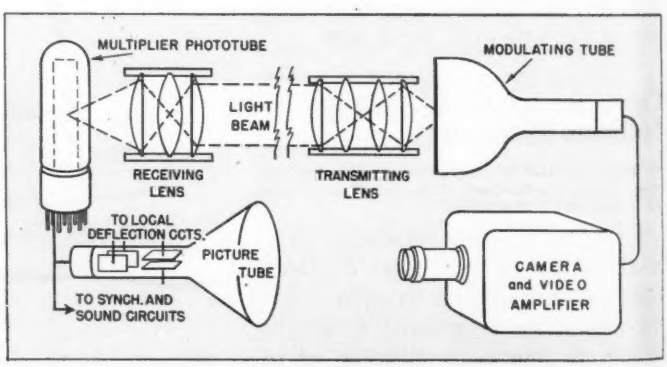
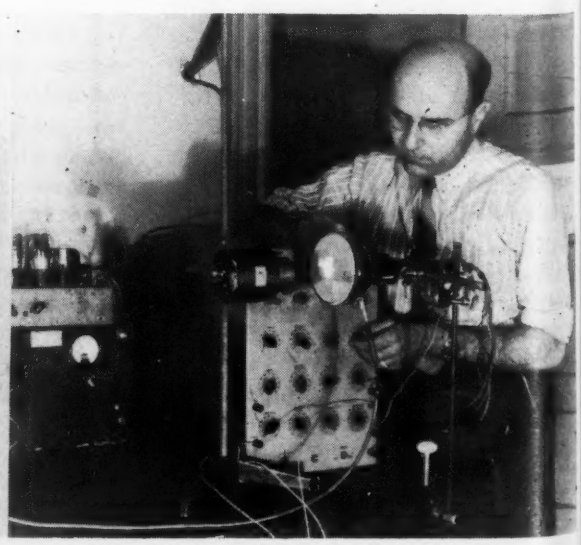


Fig. 1 (Right) — Schematic of the modulated light-beam set-up. Fig. 2 (Left) — Receiving photocell and picture tube. Fig. 3 (Right) — Modulating tube and lenses



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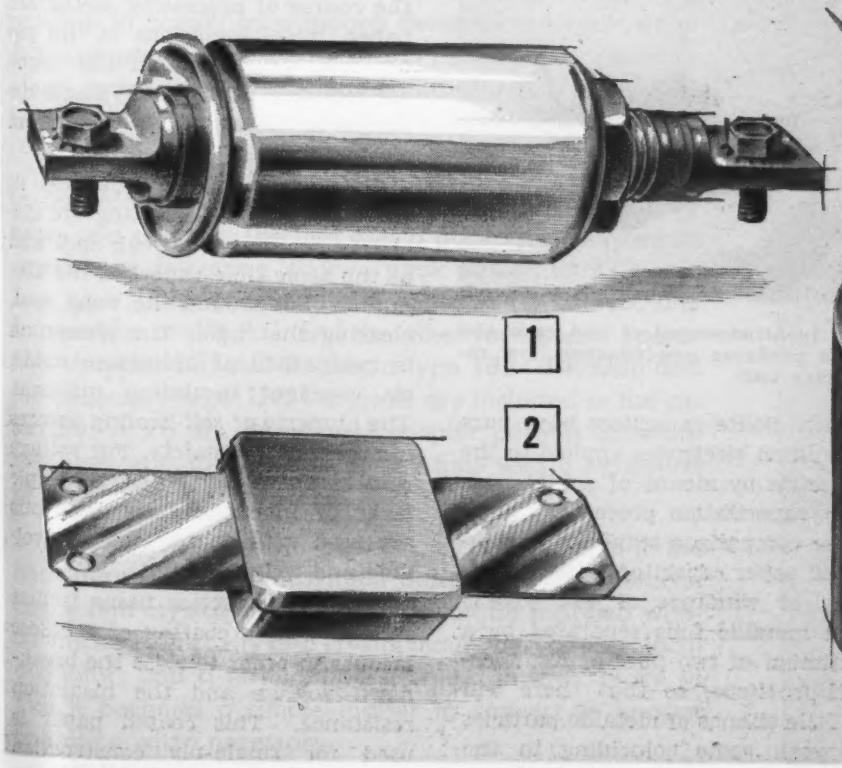
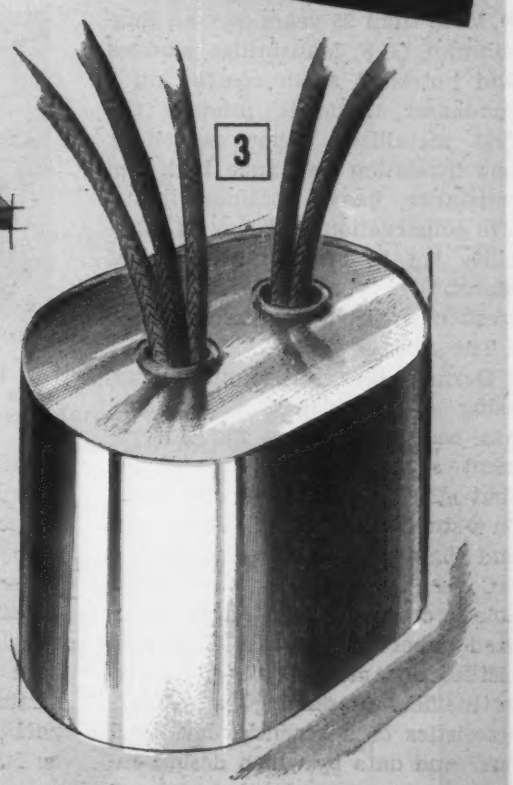




CAPACITOR #1 — A heavy-duty, hermetically-sealed, oil-filled and impregnated feed-through noise filter designed to meet the needs of an aviation application. Terminals with palnut assembly for either bulkhead or chassis mounting.

CAPACITOR #2 — This mica capacitor is molded in a low-loss phenolic case with strap terminals to provide low impedance path of high frequencies. Designed for h-f by-pass circuits.

CAPACITOR #3 — An inexpensive, completely-integrated noise suppressor incorporating both inductance and capacitance in basic design. Assembly into parent equipment reduced to five operations where normally ten would be required.

was ample to cover much greater distances. The use of well-known expedients such as higher beam powers, and more sharply focused optical systems will permit distances of a few miles or more.

High spectral conversion of the beam current is possible since the small spot usually required with scanning methods is no longer needed. The spot diameter is limited only by the beam angle requirements of the optical path. The diagram shows the sending and receiving positions of the demonstration setup.

In a such a system the television receiver circuit is much simplified by elimination of all rf and IF stages, since the output of the photo-multiplier tube is sufficient to modulate a picture tube directly (unless a special video stage is included for impedance matching or for black-to-white reversal reasons.) Both the video synchronizing and sound signals can also be included in the optical wave and may be utilized in normal ways.

The system is the outgrowth of an invention patented by Dr. DuMont on December 18, 1934. It is interesting to note that the system uses a "carrier" frequency of some 600 mega-megacycles and frequency stability is not a matter of concern practically or legally. In fact, this whole communication system seems to be beyond the jurisdiction of the Federal Communications Commission.

Point-to-point tests of the system over extended distances, both for black-and-white and color scenes are being planned, as well as studies of the requirements for the television broadcast service. Associated with Drs. DuMont and Goldsmith in this project were Rudolf Feldt, Carl Berkley, Stanley Koch, T. Rutherford, and A. Stedman.

Metallized Capacitor Dielectrics

By JAMES I. CORNELL, V-P in Charge of Engineering, Solar Mfg. Co., New York

Light weight self-healing paper dielectric capacitors result from application of new process for vaporized metallic film coatings

● More than 25 years ago, an Englishman, G. F. Mansbridge, sludged and hotrolled a tin coating on a condenser tissue to produce the first metallized paper capacitors. Low insulation resistance, high film resistance, heavy coatings, inductive construction and lack of reliability led to only limited use of Mansbridge-type capacitors in voice-frequency wire communication.

The process of Robert Bosch A.G., a German electrical manufacturer, using a vapor-deposited zinc-film, has been the source for Government-sponsored well-intentioned (but misinforming) publicity based on a survey of the Bosch equipment and plant by Allied technicians.

Consequently, it appears desirable to clarify the subject of metallized paper capacitors with a true picture of American developments in this field, presenting useful characteristics of a recently developed line* and data by which design engineers may properly evaluate and apply them to their circuit requirements. Solite capacitors have pure aluminum electrodes applied to the dielectric by means of a high vacuum vaporization process.

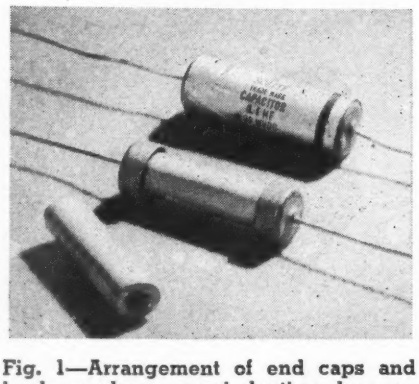


Fig. 1—Arrangement of end caps and leads produces non-inductive, low resistance unit

For comparison standard impregnated paper capacitors consist basically of windings of two 0.00035 inch metallic foils separated by a minimum of two plies of Kraft capacitor tissue, so that there will be little chance of metallic particles or weak spots coinciding in the tissue.

In Solite capacitors the self-healing property is due to the deposit of 25 to 100 millimicron thick metallic coatings, permitting the use of a single sheet dielectric. During the course of processing metallized paper, metal inclusions in the paper and weak spots in the tissue are removed, allowing the single tissue to be worked at its maximum electrical stress.

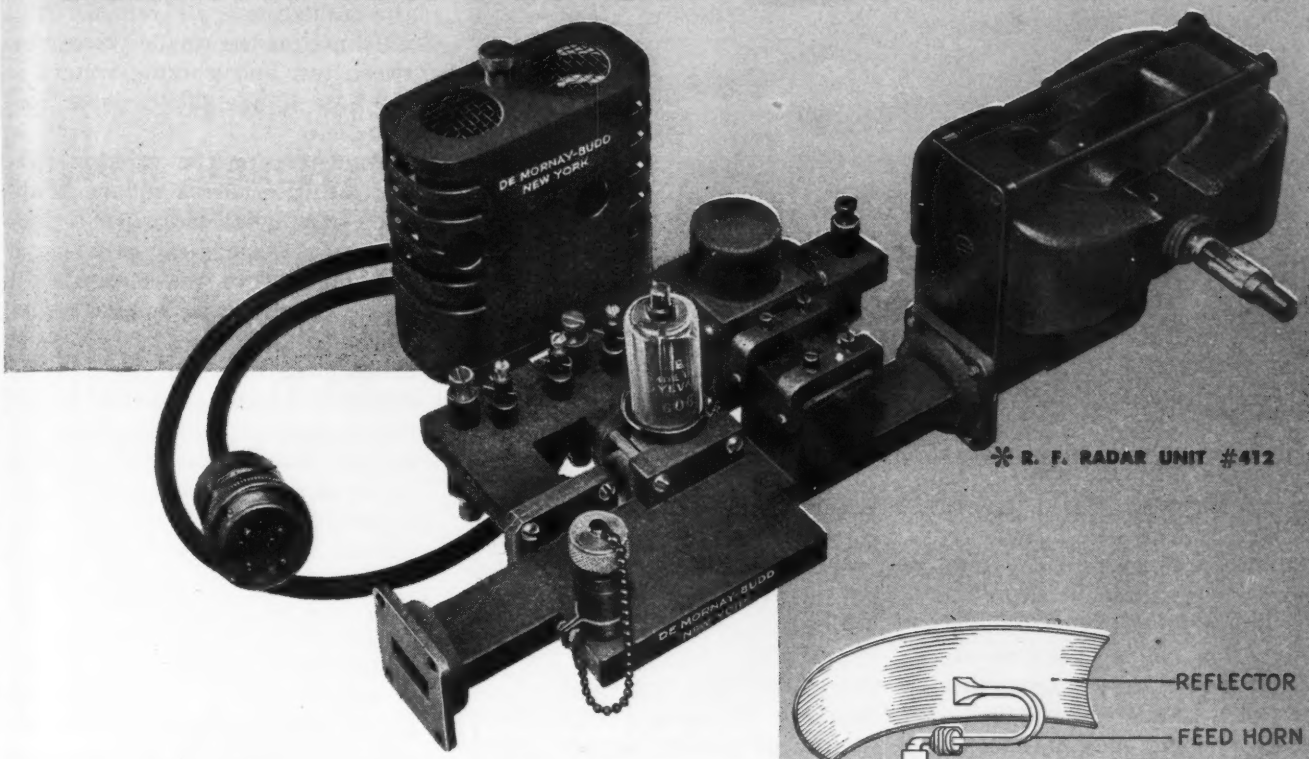
Should a weak spot develop in the dielectric, the resulting arc discharge removes the weak spot and at the same time vaporizes the aluminum film around the weak spot, clearing the fault. The aluminum is redeposited as aluminum oxide, an excellent insulating material. The property of self-healing assures a large factor of safety. For voltage ratings above 200 WVDC, multiple layer or interleaved constructions are used with consequent less volume and weight saving.

Ordinary capacitor tissue is first treated with a coating of cellulose lacquer in order to raise the breakdown voltage and the insulation resistance. This coated paper is used for single-ply construction (200 WVDC rating or lower), while uncoated paper is customarily used for interleaved construction (above 200 WVDC).

(*Continued on page* 100)

*Sold under the trade name "Solite" (coined to identify the capacitors both with Solar Mfg. Corp. which pioneered in the development of metallized coatings and one of the principal characteristics of the product — light weight).

PACKAGED R. F. RADAR ASSEMBLY ELIMINATES DESIGN HEADACHES



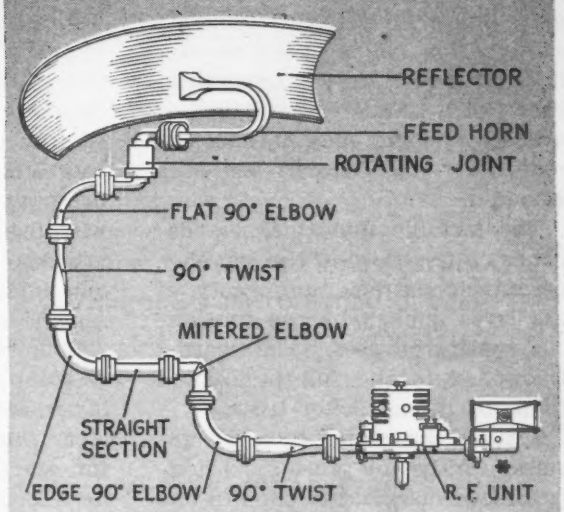
* R. F. RADAR UNIT #412

The DeMornay-Budd packaged R. F. Unit provides a complete R. F. assembly for microwave radar. It is now possible to obtain as standard items all the microwave R. F. components necessary in the fabrication of a complete radar—DeMornay-Budd Standard Transmission Line Components plus packaged R. F. Unit.

The R. F. Radar Unit is delivered complete and ready to operate. It is wired and contains all the necessary tubes and crystals. The unit uses a packaged magnetron capable of delivering 20 kw., peak power, at 9375 mc. Two type 2K25 local oscillator tubes are provided, one for receiver and A.F.C. and the other for beacon operation. A type 1B35 A-T-R tube, a type 1B24 T-R tube and the necessary type 1N21 crystals are included in the assembly. A 20 db. directional coupler permits accurate measurements to be made at any time with a maximum of convenience and safety.

Since the use of radar beacons is contemplated in the near future, the unit has been designed with a beacon cavity and crystal mount. The unit can be supplied without the beacon cavity and crystal mount and beacon local oscillator, and a termination supplied in their place so that it becomes a simple matter to convert to beacon operation when necessary.

NOTE: Write for complete catalog of De Mornay·Budd Standard Components and Standard Bench Test Equipment. Be sure to have a copy in your reference files. Write for it today.



R. F. Radar unit #412 (indicated by asterisk) used in conjunction with standard DeMornay-Budd transmission line components.

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EQUIPMENT FOR 97% OF ALL RADAR SETS

DE MORNAY-BUDD, INC.
475 GRAND CONCOURSE, NEW YORK, N. Y.

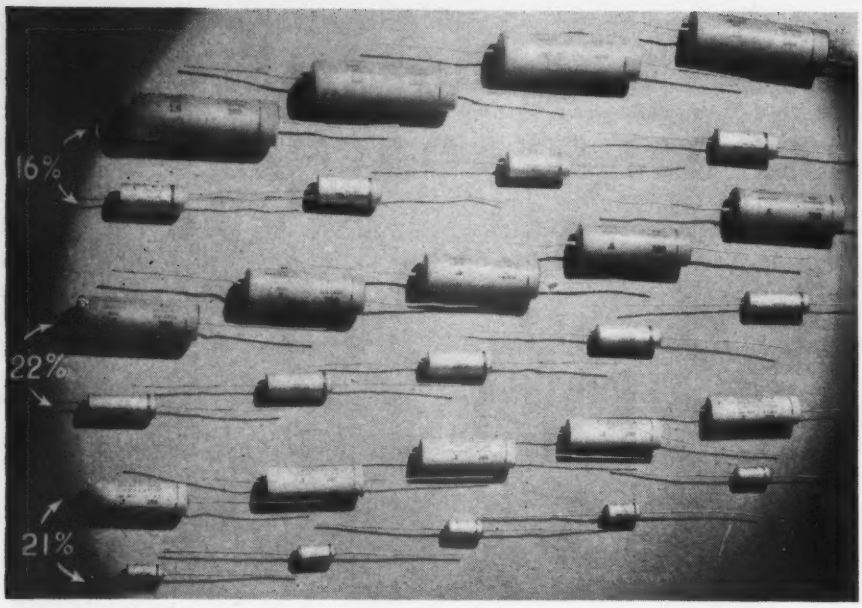


Fig. 2—New type units occupy space about one-fifth that of regular units shown above

Aluminum was chosen for the metallic coating after extensive tests, although the problem of applying the aluminum coating was quite difficult to solve. A comparison of the boiling point of aluminum (1000°C at 10 microns pressure) with that of zinc (340°C at a lesser vacuum) may indicate one reason for the German use of a zinc film.

The metallic film thickness depends on the speed of the machine, permitting extreme uniformity of the layer applied by the continuous coating process. The coating is applied to the full jumbo roll width of the capacitor tissue.

Slitting the paper into the required widths and providing a non-metallized margin, are done in one operation. Auxiliary metal roller discs, attached to a conventional slitting machine, are connected to a source of direct voltage, causing a removal of the metallic film in much the same way as in the process of "self-healing". The paper is then slit in the center of the narrow path which has been completely cleared of metallic particles. The other edge of the capacitor tissue is slit directly through the metallized surface. This method of slitting results in so-called "right hand" and "left hand" rolls which must be paired in winding in order to provide a clear margin on opposite sides of the two metallized tissues in each capacitor section.

An ingenious patented method of winding produces a non-inductive capacitor and provides a positive connection between section and terminal pigtail which is considerably stronger than that usually found. During winding of the sections, the metallized edges of the capacitor tissues are edge-turned slightly to provide surfaces which can be bonded together by a metallic spray. Metal and caps, to which wire pigtails have been previously attached, are then soldered to the end surfaces of the capacitor sections (Fig. 1).

Microcrystalline hydrocarbon wax is used for impregnating single layer windings and for multiple layer windings which are intended for operation at temperatures up to 70°C, and mineral oil is used in interleaved sections intended for use up to 85°C.

In order to properly apply such capacitors to electric circuits, a thorough understanding of these characteristics and the manner in which they have been determined is very necessary.

The rating of metallized paper capacitors must be considered entirely afresh from the criteria we have all grown accustomed to for conventional paper capacitors.

For example, a breakdown test of two to three times rated working voltage has been considered standard for small capacitors of conventional design. This does not hold for metallized paper units where the test voltage must be restricted to 1.5 times the working voltage. This in no way indicates that this is a less satisfactory construction.

The self-healing properties increase the working voltage stress since the removal of the incipient faults in the dielectric has made the insulation more reliable. This accounts for the smaller spread between test and working voltage in the case of metallized paper construction.

To determine the working voltage rating, a direct voltage is applied to a metallized paper capacitor and a cathode-ray oscillograph is connected to the circuit as a means for detecting voltage breakdown, to show up the occasional breakdowns of weak spots in the dielectric paper as the test potential is increased. In time these incipient faults clean and there is no further indication of spark discharge.

If the capacitor is subjected to a voltage close to its ultimate breakdown voltage[1] or to its sparking voltage[2], the metallic coating would rapidly deteriorate as minute areas of film would be "taken out" by each discharge until an appreciable area would be "robbed" from the winding. If the sparking voltage is applied long enough, the ultimate result would, of course, be complete self-destruction of the capacitor.

Breakdown vs. Voltage

By plotting the frequency of breakdowns as a function of the test voltage, it is possible to readily determine the sparking voltage and to set the rated working voltage at such a value that there will be negligible arcing or spark discharges in actual service. In rating Solite capacitors, the working voltage has been consequently set at about 60% of the sparking voltage under the worst conditions.

As the operating temperature of the capacitor under test is increased, the frequency of breakdowns at a given test voltage is also increased. Consequently, it is necessary to de-rate the capacitor

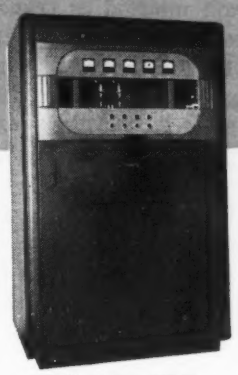
(*Continued on page* 156)

1. Ultimate breakdown voltage may be defined as the lowest applied voltage which will cause carbonization of the dielectric and short-circuiting of a capacitor.

2. Sparking voltage may be defined as the lowest applied voltage which will cause continuous "self-healing" action to take place in a metallized paper capacitor.

FM for the Best in Broadcasting

Collins for the Best in FM



Collins Type 731A
250 watt FM transmitter

In FM, Collins gives you: advanced engineering, efficient operation, simplified design, Phasitron modulation, maximum accessibility, personnel protection, unit construction, flawless performance, dependability.

Collins FM utilizes the Phasitron modulation system. Direct crystal control of the carrier frequency eliminates complicated reference circuits, and permits the use of conventional quartz crystals, with simple temperature control. Only 6 multiplier tubes are employed to produce the transmitted frequency. FCC specifications are amply fulfilled in every detail. Unit construction facilitates increasing power at any time.

Years ago, Collins pioneered the use of vertical chassis construction for accessibility. Maintenance of Collins equipment is a simple task. All operating controls are easily reached from the front of the cabinet, while the transmitter is on the air. Electrical and mechanical interlocks provide maximum personnel protection when doors are opened.

The 731A, shown above, is one of a line of Collins FM transmitters which reflect many years of successful experience in the design and manufacture of outstanding broadcast station equipment. Tell us about your plans and ask for descriptive literature covering our FM transmitters and studio equipment. We can supply your entire needs from microphone to antenna.

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COLLINS RADIO COMPANY, Cedar Rapids, Iowa

11 West 42nd Street, New York 18, N. Y. 458 South Spring Street, Los Angeles 13, California

WASHINGTON

Latest Electronic News Developments Summarized
by Electronic Industries' Washington Bureau

1947 PRODUCTION OUTLOOK—With effects of the industrial paralysis from the coal strike and freight embargo still difficult to evaluate and to unscramble, the radio-electronics and communications manufacturing industries commence the New Year under a handicap, but with prospects, provided labor peace can be achieved in the near future, of establishing during this year the highest peacetime production on record.

RECEIVER COMPETITION — Radio receiver production, which in 1946 set a new mark in peacetime manufacture and was achieved generally for the Christmas market, is geared toward the higher-priced combination (AM-FM and in many cases TV) sets and console sets of which very few will be without phonographs. The table model receiver market in the United States is declining with the public turning to the higher-priced combinations and consoles, now they are becoming available. Another significant factor has been the softening of prices of the lesser known name types of table models. All in all, mark up 1947 as probably the most highly competitive year in radio manufacturing's history.

U.S. SYSTEMS IN AVIATION NAVIGATION GAIN APPROVAL—Strong gains for the U.S. systems of radio and radar air navigation aids were recorded in the approval of the PICAO Special Radio Technical Division. The RTD composed of representatives of 27 nations placed its sanction on U.S. instrument landing system, developed by Civil Aeronautics Administration and Federal Telephone & Radio and refined by Army Air Forces, for blind landing method at international airfields and directed installations of this system be completed by January, 1951. Also recommended was the VHF omni-directional radio range system with distance measuring equipment (DME); and LF Loran system, developed by Hazeltine Corp., which was recommended for further study through chains of stations set up in southeast Asia, Africa, Australasia, Pacific Islands and South Atlantic. Adoption of American systems for international flying means hundreds of millions of dollars in new navigational equipment for U.S. manufacturers.

TELEVISION SURVEY—For more than a week during mid-December FCC engaged in a most important inquiry into the future of television. It was a battle between the CBS color TV system on which through sequential processes color would be built on black-and-white, and the RCA all-electronic color video system, termed the simultaneous system method and claimed as the natural way of building color into video. FCC Commissioners and technical staff, which had previously viewed the RCA and Philco television operations spent Dec. 16 in seeing the latest CBS methods and DuMont's station in New York with its newest light-beam method of transmission, already viewed in a special demonstration by Commission in Washington. Leading manufacturers, like RCA, Philco, Farnsworth, General Electric, Westinghouse, Bendix, Zenith, Federal Telephone & Radio and Telecon, presented their reports on latest status of transmitter and receiver manufacturing, production outlook (forecast as 350,000 sets in 1947), type of sets and technical characteristics. FCC decision will take time as so important and controversy-charged a matter cannot come probably before mid-January.

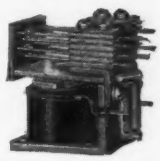
FREQUENCY SPACE CROWDED — Mobile radiotelephone services—urban and highway, taxicab, police, fire, forestry, utilities and transit, together with plane-to-ground public telephony — is undoubtedly the FCC's fastest-growing radio service. Little-publicized because of being overshadowed by the new broadcasting fields of FM and television, mobile radio now has some 30,000 stations on the air or authorized and 1947 is slated to see double that number or at least 50,000. It is "big business", too, —witness amount of money projected in each week's batch of FCC applications for urban-highway mobile and taxicab installations, averaging around $500,000. And services are still experimental. As result of flood of applications and outlook—(look at the figures, total of 27,000 police transmitters by next year, 5,000 forestry conservation, 14,000 municipal fire stations by end of 1948, 15,000 urban-highway, 10,000 taxicabs at minimum)—radio manufacturers and users of services are insistent upon more frequency space. During January oral argument on 30-40 and 152-162 mc bands with allocation of more channels and frequencies is to bring issue to head before Commission.

National Press Building
Washington, D. C.

ROLAND C. DAVIES
Washington Editor

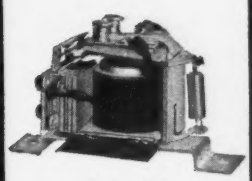
Relays BY GUARDIAN

FACTORY STANDARD WITH SPECIAL VARIATIONS



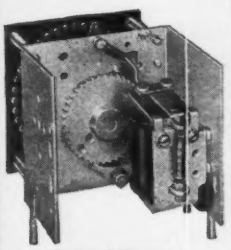
Series 500
Midget Relay

Use this relay where space, weight and maximum power delivery are primary factors. Sturdy. Offers many contact combinations. Maximum contact control capacity 8 amps. Fits in approximately 1½ cu. in. space.



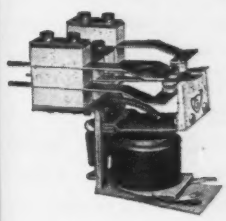
Series 150

Suitable where a small A.C. control relay is needed or if exposed to possible maladjustment. Equipped with "special" spring tension contacts which "make" before the armature fully completes its travel. Remaining armature movement is taken up by the contact coil spring insuring a firm, wiping contact.



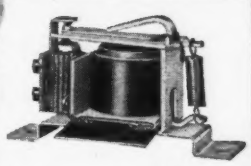
Series R Stepper

Three basic types for A.C. and D.C. operation: (1) Continuous rotation, (2) Electrical reset, (3) Add and subtract. For automatic circuit selection including automatic sequence; automatic wave changing on short wave transmitters; business machines; totalizers; conveyor controls, etc.



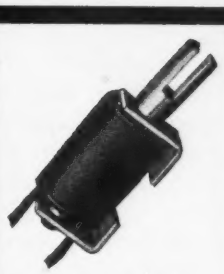
Series A-100
High Frequency

A1SiMag insulated, compact, low cost. For antenna changeover; break-in; hi-voltage keying; remote control of receiver and transmitter and other high frequency applications.



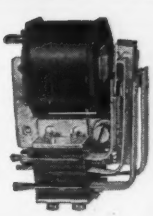
Series 120

A small, compact relay. An economical unit designed for control up to single pole double throw. Unique armature assembly prevents arcing. Low priced, yet high in quality and performance.



Series 1-A Solenoid

The series 1-A Solenoid by Guardian is one of numerous types for intermittent and continuous duty. Applications include valve control and operation; electrical locking; clutch and brake operation; material ejection; spray gun operation among others.



Series 40 A.C.
Laminated Relay

Designed to produce maximum output with minimum current input. Typical uses include control of call system bells; auxiliary for automatic radio tuning; remote control of fractional motors; safety devices; instruments; sound movie auxiliaries.

Guardian Switches

Switch assemblies by Guardian are unlimited, ranging from a single set of contact blades up to multiple stacks. The Guardian Featherub Switch shown is actuated mechanically. Operates on manual, roll-over or cam action. There are hundreds of others. Contact blades are obtainable in phosphor bronze, tinned to withstand salt spray test, or standard Guardian phosphor bronze.

Introducing a new product? Redesigning an established favorite? You may be thinking in terms of a "special" electrical control. Yet, a *basic* type Guardian Relay—Stepper—Contactor—Solenoid—or Switch Assembly (each adaptable to many variations) may meet your "special" control requirements with utmost efficiency. In such applications where *standard* Guardian units become "specials," the savings in time and money are substantial and you beat delivery schedules in the bargain. We urge you—study the *standard* Guardian units pictured and described above—there are many more fully illustrated in the Guardian Relay catalog giving complete operating details and variable contact data for each. Your copy is waiting. Write.

GUARDIAN ELECTRIC

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News of the Industry

Color-TV Controversy Argued Before FCC

The extensive research work done by CBS on color television was revealed during the FCC hearings at Washington in December. Expenditures, made under the direction of Dr. Peter Goldmark, have been much greater than most engineers have realized.

"The outcome, now revealed in its entirety for the first time", said one technical observer at the FCC hearings, "impressed engineers and commissioners because the resultant equipment is well-engineered and functions well. Back of the tests that were divulged, excellent technical planning is evident, and the pictures in color which have been shown, are good. Before FCC, CBS did a 100% job of statement, arrangement and presentation."

Engineering Director Lodge (CBS) added about 50% new material to his paper given before the Chicago Electronics Conference in October, and presented this combined testimony at the hearing. Dr. Goldmark also read a 74-page discussion.

Chairman D. B. Smith (Philco) of the RMA TV Color-Standards Committee, presented the report of his committee, giving an unbiased statement covering most of the important points at issue in the color-TV controversy. The questionnaire indicating committee members' views, also attracted great interest.

Still Four Years Away

Dr. C. B. Jolliffe, executive vice-president of the RCA Laboratories, which have produced an electronic system of color television, warned that color TV is at least four years away. "Much work remains to be done before a determination can be made as to the proper standards for a system of color television which should ultimately be adopted. To adopt standards now will probably result in no television rather than in improved television."

Charles R. Denny, formerly FCC Counsel, lately Acting-Chairman, has been appointed Chairman of FCC by President

Dr. Jolliffe declared his corporation would continue vigorous research and development work in both monochrome (black-white) and color television "with all the resources at our commond, regardless of the status of operations, manufacture, or adoption of standards. We will not cease in our efforts to improve service to the public," he said.

J. E. Brown, Zenith, supported the CBS position. Ralph Harmon, Westinghouse, approved the CBS sequential system as the best color method now in sight. B. Ray Cummings, Farnsworth, supported the RCA position against haste in adopting color standards, pointing out that black-white is now giving thoroughly satisfactory service to the present television audience.

NAB Appoints Engineering Executive Committee

Among other routine business matters, National Association of Broadcasters named four industry committees during December meetings. Among them the Engineering Executive Committee includes these members: Orrin Towner, WHAS, Louisville, Ky., chairman; James Ebel, WMBD, Peoria, Ill.; Ross Beville, WWDC, Washington, D.C.; R. V. Howard, KSFO, San Francisco; Roland C. Hale, WCOP, Boston; Oscar Hirsch, WKRO, Cairo, Ill.; G. Porter Houston, WCBM, Baltimore; O. B. Hanson, NBC, New York; William B. Lodge, CBS, New York; Earle M. Johnson, MBS, New York.

Test Railroad 'phone

In a grant of the first application of its kind, the Illinois Bell Telephone Co. has been given construction permits by the FCC to set up a radiotelephone land station and install 32 mobile units for the Atchison, Topeka & Santa Fe Railway Co. to test possibilities of the telephone company furnishing a general railway service. Purpose of the tests, according to the application, is to determine whether the telephone company can provide a service to railroads comparable to urban and highway mobile. The railroad would be provided with equipment by the Illinois Bell on a rental basis with fixed monthly charges for maintenance.

CONVENTIONS AND MEETINGS AHEAD

Materials Handling Exposition—Public Auditorium, Cleveland, Ohio, January 14-17.

Electrical Engineering Exposition—71 st Regiment Armory, New York, January 27-31, International Expositions Co., 480 Lexington Ave., New York.

American Institute of Electrical Engineers—Winter Meeting, 33 W. 39th St., New York. H. H. Henline, secretary, 33 W. 39th St., January 27-31.

7th International Heating and Ventilating Exposition—Lakeside Hall, Cleveland, Ohio, January 27-31 concurrently with the **53rd Annual Meeting of the American Society of Heating and Ventilating Engrs.**

Industrial Electrical Equipment Exposition—Auditorium of the Wisconsin Electric Power Company, Milwaukee, Wis., January 30-31.

American Society for Testing Materials—**Spring Meeting**—Benjamin Franklin Hotel, Philadelphia, Pa., February 24-28. **Annual (15th) Meeting**—Chalfonte-Haddon Hall, Atlantic City, June 16-20.

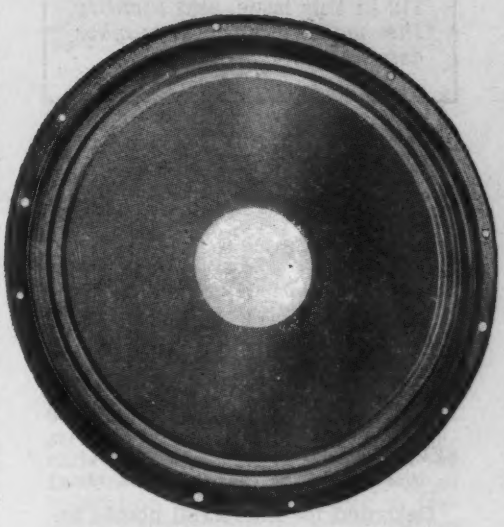
Institute of Radio Engineers—Annual Meeting (Commodore Hotel) and Show (Grand Central Palace), New York, March 3-7.

Society of the Plastics Industry—Annual Convention (Stevens Hotel) and National Plastics Exposition (Coliseum), Chicago, May 5-11.

1947 Radio Parts and Electronic Equipment Conference and Show—Stevens Hotel, Chicago, May 13-16.

Radio Manufacturers!

NOW YOU CAN USE ALTEC LANSING SPEAKERS . . . AN ADDITIONAL MARK OF QUALITY, ANOTHER SELLING POINT, FOR YOUR FINE RECEIVERS.



THE ALTEC LANSING DIA-CONE SPEAKER

Model No. 600

When a radio manufacturer we know heard the famous Altec Lansing Duplex, his first words were: "You ought to design a speaker like this for my better receivers . . . at a price I can afford." And here it is . . . a popular priced speaker with a carry-over of Altec Lansing's premium priced features. This new model, No. 600, is a 12-inch edition of the Altec Lansing line. Now you can identify your finer receivers with Altec Lansing quality. Send for further technical information on the No. 600.

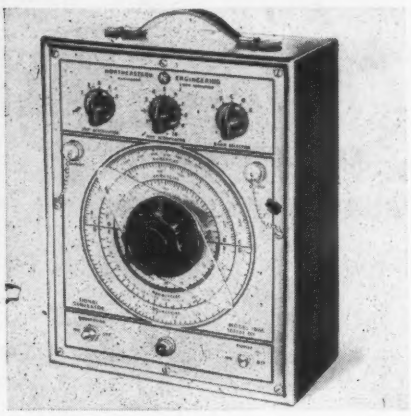
MODEL No. 600: Specially designed for better radio-phonographs. This Altec Lansing Dia-Cone Speaker incorporates a metal high frequency diaphragm and a 12-inch low frequency cone, coupled by a unique mechanical dividing network to a 3-inch voice coil of edgewise wound aluminum ribbon.

ALSO AVAILABLE IN 15-INCH DIA-CONE WITH A MULTICELLULAR HORN FOR HIGHER PRICED COMBINATIONS

"KEEP ADVANCING . . . WITH ALTEC LANSING"

ALTEC
LANSING CORPORATION
1161 N. Vine St., Hollywood 38, Cal.
250 W. 57th St., N. Y. 19, N. Y.

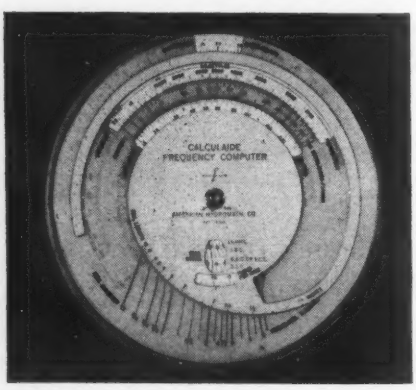
New Lab and Test Equipment



SIGNAL GENERATOR

(Use Inquiry Card, Mentioning No. 11)

A frequency range from 160 kc to 20 mc can be covered on fundamental frequencies in five bands by model 700A signal generator, which provides a sixth band for special calibrations. Internal modulation is approx. 30% at 400 cycles with an af output voltage of 2 V.rms. RF output is adjustable from 0-0.1 volts, the output impedance being 200 ohms. The unit operates on 105-125 volts, 60 cycles, ac and consumes 12 watts.—*Northeastern Engineering Inc., Manchester, N. H.*



FREQUENCY COMPUTER

(Use Inquiry Card, Mentioning No. 12)

Problems involving frequency, inductance and capacity are quickly solved with the "Calculaide" frequency computer, which correlates in one setting the natural frequency and wave length of a circuit comprising a coil and capacitor with the physical dimensions of the coil and the capacitance value. Inductance values can be determined for widely varying physical dimensions from the smallest single-layer receiver coil to high power transmitting coils. The computer has a frequency range from 400 kc to 150 mc, a capacity range from 3 to 1000 mfd, and inductance values from .1 to 1500 micro-henrys. It is made of Vinylite and has a diameter of 6¼ in.—*American Hydromath Co., 145 W. 57th St., New York 19.*

ANNOUNCEMENT

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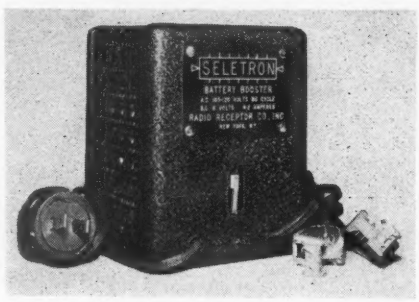
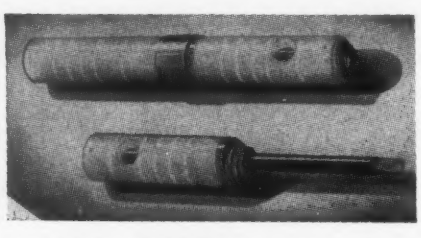


SELENIUM BATTERY CHARGER

(Use Inquiry Card, Mentioning No. 13)

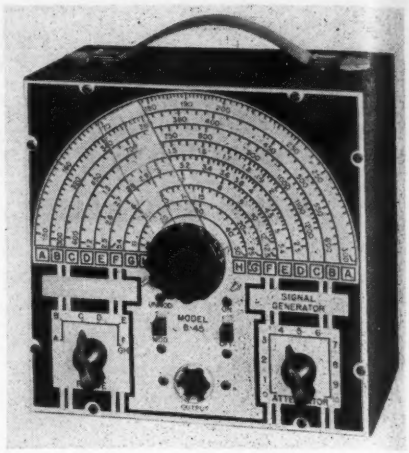
Designed for industrial plants using 6-volt storage batteries for the operation of alarm and signal systems, or similar applications, the Seletron automatic, constant voltage battery charger, rated at 2-4 amps, will supply 5 amps for short periods of time. The compact, lightweight battery booster uses a long life selenium rectifier for trickle charging and is provided with an automatic circuit breaker for overload protection. The unit operates on 105-120 volts, 60 cycles, ac.—*Seletron Div., Radio Receptor Co., 251 W. 19th St., New York 11.*



CURRENT CHECKER

(Use Inquiry Card, Mentioning No. 14)

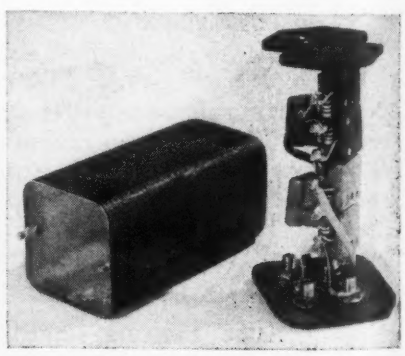
A combination electrical testing instrument and screwdriver will test all commercial currents and electrical appliances by means of a neon bulb housed in the catalyn case of the screwdriver. Designed for one-hand operation the Tes-L-Lamp will indicate electrical current by removing the cap and placing the screwdriver tip in the socket. To test spark plugs the unit is left intact and the screw on top of the cap is touched to the plug.—*Allaire Associates, 11 Commerce St., Newark, N. J.*



SIGNAL GENERATOR

(Use Inquiry Card, Mentioning No. 15)

A low-cost, 1-tube signal generator, model B-45, provides stable rf frequencies from 150 kc 12.5 mc on fundamentals, and from 11 mc to 50 mc on harmonics, obtainable separately or af-modulated. The generator is portable, operating on self-contained standard size 1½ V. and 45 volt batteries. Using a grid-blocking action for modulation, the instrument is equally suitable for alignment of AM, FM, or television. —*Metropolitan Electronic & Instrument Co., 6 Murray St., New York, N. Y.*



WIEN BRIDGE HUM FILTER

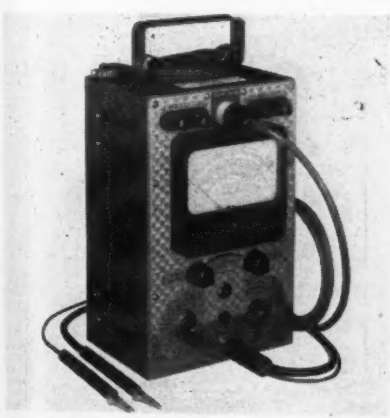
(Use Inquiry Card, Mentioning No. 16)

A simple filter to completely cancel 60 and 120 cycle hum in oscillograph and vacuum tube voltmeter applications consists of two Wien bridges in cascade. The first one is balanced for 120, the second for 60 cycles, using only fixed capacitors and resistors. Terminals are brought out for separate use of the bridges in hum-analysis and trouble shooting. Components are mica capacitors and low temperature coefficient resistors. The whole assembly is sealed in polystyrene.—*Kalbfell Laboratories, 1076 Morena Blvd., San Diego 10, Cal.*

CAPACITOR ANALYZER

(Use Inquiry Card, Mentioning No. 17)

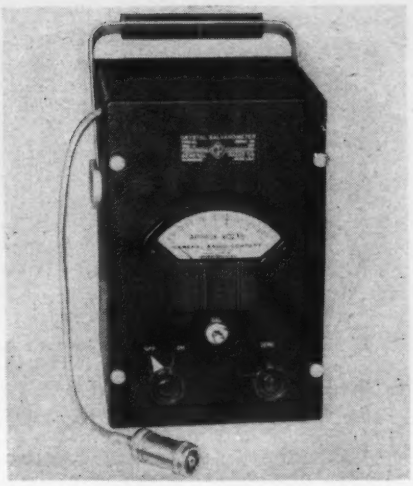
Especially designed for the electronic industry and with improved components for use in humid climates the new model CBB light weight capacitor analyzer will measure capacitors from 10 mmfd to 800 mfd. "Magic Eye" tube is used for Wien bridge balance indication, while visual checks of insulation resistance and leakage current are made by means of neon lamp tests. The instrument also may be used as a line frequency resistance bridge covering a range of 50 ohms to 2 megohms.—*Solar Mfg. Corp.*, 285 *Madison Ave., New York* 17.



ELECTRONIC CIRCUIT TESTER

(Use Inquiry Card, Mentioning No. 18)

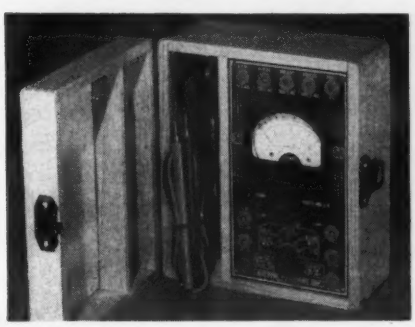
Performing 28 primary functions, Model 7001 electronic circuit master has been developed to fill the requirements of sound, radio, FM, television, and electronic equipment testing. Ac and dc voltages may be measured in 8 ranges up to 10,000 volts, resistance in 7 ranges up to 1500 megohms, capacity to 300 mfd, alternating current from 0-30 amps in one range, and direct current in ranges of 1, 10, 100, 1000 ma, and 30 amps. Decibels are covered from — 16 to + 6 db. With the optional probe head rf measurements can be made up to 200 mc. The unit is stabilized for line voltage variation between 105 and 120 volts, 60 cycle, ac. Accuracy on voltage, current, and capacity ranges is 3% of full scale.—*Philco Products, Inc., Tioga & C Sts., Philadelphia* 34, *Pa.*



UHF VOLTMETER

(Use Inquiry Card, Mentioning No. 19)

For direct voltage measurements in the uhf range, the Type 1802-A crystal galvanometer is similar to a peak-reading vacuum tube voltmeter, consisting of rectifier and dc amplifier, but uses a crystal rectifier in the probe in place of a tube diode. This permits a frequency range for direct voltage measurements from 10 to 1000 mc and for voltage indication up to 3000 mc. Voltage range of the instrument is 0.1 to 1 volt with decade multipliers being supplied for factors of 10 and 100. Accuracy of indication is ± 5%, subject to frequency correction, for which curves are supplied. Net weight of the unit is 10¾ lbs.—*General Radio Co.*, 275 *Massachusetts Ave., Cambridge* 39, *Mass.*



VOLT-OHM-MILLIAMMETER

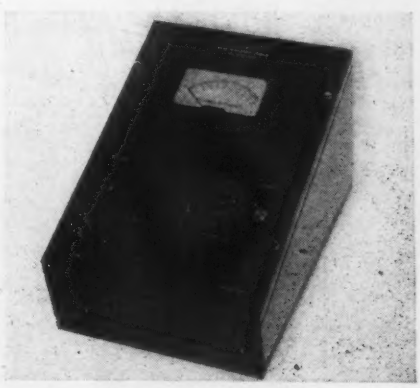
(Use Inquiry Card, Mentioning No. 110)

Resistance between 1/20 ohm and 20 megohms and ac voltages between 25 cycles and 1 megacycle can be measured with the low-cost Model 101 Volometer which is accurate within 2% of full scale. The instrument has five dc voltage ranges from 0 to 3,000 volts, 4 ac ranges from 0 to 1200 volts, 3 dc current ranges from 0 to 600 milliamps., and four resistance ranges up to 20 megohms. It is available in two versions, model 101A, and model 101B, which has a larger dial face.—*Electronic Measurements Corp.*, 114 *Liberty St., New York* 6.

PRIVATE SOUND DETECTOR

(Use Inquiry Card, Mentioning No. 111)

Now available to civilian sources such as detective agencies, private investigators, police chiefs, etc., this portable lightweight sound detector includes sensitive small room-concealment microphones, crystal wall contact microphones, telephone induction coils, sensitive headphones and other investigational equipment. The battery-operated, three-stage audio amplifier is contained in a carrying case with three separate compartments for amplifier, batteries, and auxiliary components.—*Speak-O-Phone Recording and Equipment Co.*, 23 *West* 60th *St., New York.*

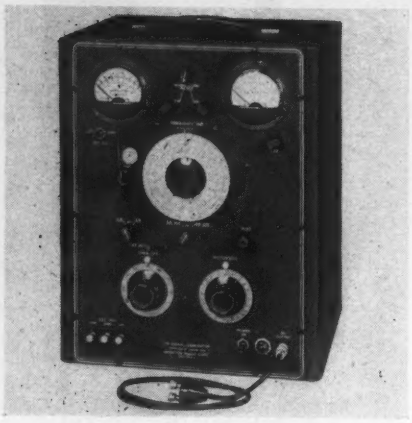


CAPACITY METER

(Use Inquiry Card, Mentioning No. 112)

Covering a wide capacitance range from 0.1 to 10,000 mmfd the direct-reading Model 201 capacitymeter makes possible rapid laboratory or production measurements of practically any mica, ceramic, or air dielectric capacitor. Capacity-to-ground effects do not affect the accuracy of the instrument, which may also be used to measure the inductance of coils from 250 microhenries to 250 millihenries. Consisting of a 100 kc oscillator in conjunction with a vacuum tube voltmeter the instrument is guaranteed to be within 2% of full scale on the ten capacity ranges. It operates on 110-120 volts, 50-60 cycle, ac.—*Maida Development Co., P.O. Box* 588, *Erie, Pa.*

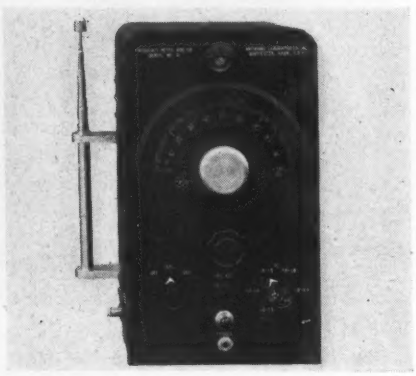
(*Continued on page* 108)



FM SIGNAL GENERATOR

(Use Inquiry Card, Mentioning No. 113)

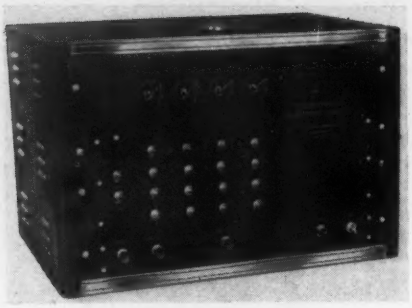
A frequency range from 54 to 216 mc with two FM deviation ranges from 0 to 80 and 0 to 240 kc can be covered with the new frequency modulated signal generator, Type 202-B. An internal audio oscillator provides 8 fixed frequencies between 50 cycles and 15 kc, and may be switched for either frequency, or 30-50% amplitude modulation. Simultaneous FM and AM may be obtained by use of an external AF oscillator. FM distortion at 75 kc deviation is less than 2%. A monitoring meter standardizes the output level and makes the rf attenuator direct reading over the range from 0.1 microvolts to 0.2 volts. Output impedance with cable attached is 26.5 ohms. The self-contained instrument operates on 115 volts, 60 cycle, ac.—*Boonton Radio Corp., Boonton, N. J.*



FREQUENCY METER

(Use Inquiry Card, Mentioning No. 114)

Useful over a continuous frequency range of 100 kc to 50 mc, the model S-6 frequency meter has an accuracy of ±.025% with the 6 in. instrument dial being readable to one part in 1000. The instrument is provided with a built-in crystal calibrator and has a fundamental oscillator range from 1.0 to 2.0 mc in five bands of 200 kc each. External signals are coupled to the meter through a telescoping antenna which also serves as carrying handle. The unit is for operation on 110-115 volts, ac or dc, and has an input of 40 VA.—*Browning Laboratories, Inc., 724-750 Main St., Winchester, Mass.*



SINGLE CHANNEL COUNTER

(Use Inquiry Card, Mentioning No. 115)

Designed to meet the requirements for high speed counting, batching and packaging of processed items such as sheet metals, buttons, hardware, cartons, etc., the single channel predetermined counter model 140 will count and control at rates of 15,000 per minute and higher. When a predetermined number of items have been counted the unit actuates a control which stops or diverts the flow of material. Four 4-tube counter decades permit setting up of any number up to 10,000. Input to the counter can be obtained from contact closures, interruption of photo-electric beams, and the like, while the output consists of a DPST high speed relay adaptable for solenoid actuation.—*Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, New York.*

UNIVERSAL EQUALIZER

(Use Inquiry Card, Mentioning No. 116)

The Bellows equalizer will match practically any desired response curve needed in broadcasting, sound, and motion picture industries. Nine different resonance frequencies and nine slopes of equalization provide 81 combinations, the values of equalization being present with a variable resistance. The units are available in the low frequency range from 30-120 cycles and the high range from 5-15 kc with operating impedances of 500 and 10,000 ohms.—*Burnell & Co., 10-12 Van Cortlandt Ave., New York 58, N. Y.*

DYNAMIC SIGNAL TRACER

(Use Inquiry Card, Mentioning No. 117)

Designed for signal tracing in rf and IF circuits the Model 7030 dynamic tester features high gain, good frequency response, and flexibility. The probe head has a lucite lens and four switch positions providing a wide choice of input impedances. At the lowest position the input capacity is small enough for use at several hundred megacycles. A dc position permits microphone and amplifier testing. The 5-in. dynamic speaker provides 2 watts output at less than 10% total harmonic distortion.—*Philco Products Inc., Tioga & C Sts., Philadelphia 34, Pa.*

THICKNESS GAGE

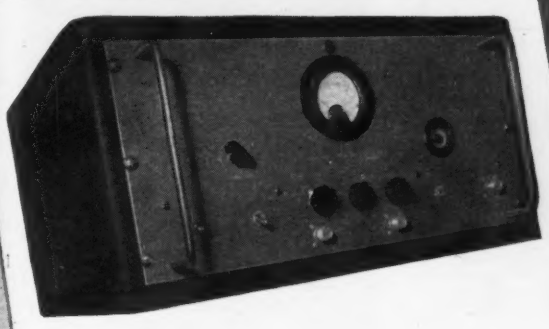
(Use Inquiry Card, Mentioning No. 118)

Applicable to steel, aluminum, brass, copper, glass and other materials, model FMSS-4 audigage thickness gage is a portable, self-contained instrument for non-destructive thickness determination of pipes, storage tanks, pressure vessels, etc. Utilizing a crystal-type gage head actuated by a frequency-modulated oscillator, the vibrating crystal applied to the wall surface produces mechanical vibrations, the frequency of which depend on the velocity of sound and the thickness of the material. The direct-reading instrument covers a range from ⅛ to 12 in. with high sensitivity and accuracy.—*Branson Instruments, Inc., Joe's Hill Rd., Danbury, Conn.*

(*Continued on page* 110)

Lavoie

UHF PRECISION INSTRUMENTS



HARMONIC FREQUENCY GENERATOR

PROVIDES harmonic output voltages in 10 or 40 mc series with crystal-controlled accuracy.

SELECTS 10 or 40 megacycles series by means of front panel switch.

USED FOR calibration of receivers, wavemeters, or (with Beat Detector built into instrument) for calibration of oscillators and signal generators. May also be used in conjunction with a low-frequency communications-type receiver to determine UHF oscillator drift. A mixer unit is available for this application.

PRECISION FREQUENCY METER

Completely portable Accuracy 0.1% Models available from 100 to 2000 megacycles with 2 to 1 frequency coverage on each model.

RECOMMENDED FOR:

- Production testing
- Measurement of oscillator drift
- Independent alignment of transmitters and receivers
- Precise measurements of frequencies

FULL DETAILS ON REQUEST

U H F

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS

MORGANVILLE, N. J.

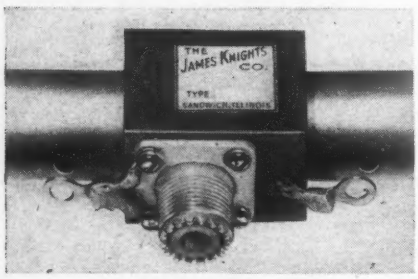
Specialists in the Development and Manufacture of UHF Equipment

Parts for Design Engineers

HIGH AMPLIFICATION TRIODE

(Use Inquiry Card, Mentioning No. 119)

An amplification factor of 500 at plate voltage ratings from 1 KV to 8 KV is possible with the NU-2C53 High Mu triode, which is particularly designed for regulation of low current power supply voltages up to 8 KV. High positive or negative potentials may be applied between heater and cathode without danger of breakdown. Filaments operate at 6.3 volts, .3 amps., plate resistance is .525 megs, and transconductance is 950 umhos. Average plate currents is 5 ma, peak 100 ma, plate dissipation being 12 W. The tube is also suitable in pulse amplifiers and TV applications.—*National Union Radio Corp., Newark, N. J.*



UNIVERSAL ANTENNA CONNECTOR

(Use Inquiry Card, Mentioning No. 120)

Designed for making a secure weatherproof junction between Amphenol "RG" type flexible coaxial line and any current fed antenna or array the J-K Impedacoupler can also be used with Amphenol "flat" lines or with the usual type of open wire lines. Equipped with type 1R receptacle, the coupler requires the addition of a type 1SP cable connector on the end of the line for a quick, positive connection. The center insulating block is made of mykroy. The insulator ends are machined to fit the inside diameter of standard aluminum or dural tubing having 1 in. outside diameter.—*The James Knights Co., Sandwich, Ill.*

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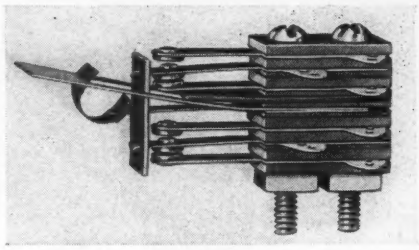
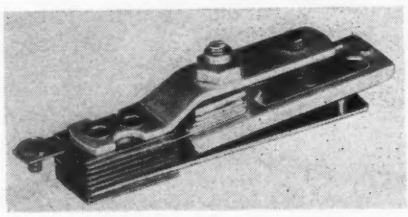


SNAP-ACTION SWITCH

(Use Inquiry Card, Mentioning No. 121)

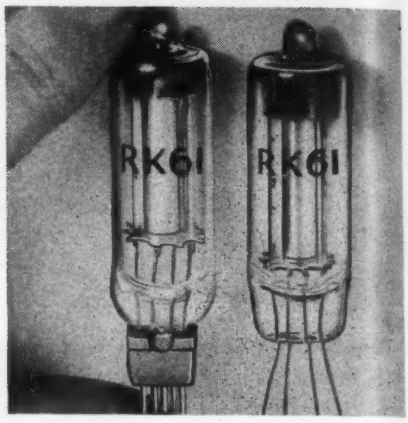
Constructed with a berryllium rolling spring, and made with single and double throw contacts, this compact, snap-action open blade switch has been designed for 2-pole applications. Standard operating pressures are from 3 to 5 oz. Overall dimensions are 2⅛ in. x 25/32 in. x ⅜ in. The unit is rated at 15 amps., 125 volts, ac, with a movement differential of approx. 1/16 in.—*Acro Electric Co., 1308 Superior Ave., Cleveland 14, Ohio.*



THERMAL CUT-OUT SWITCH

(Use Inquiry Card, Mentioning No. 122)

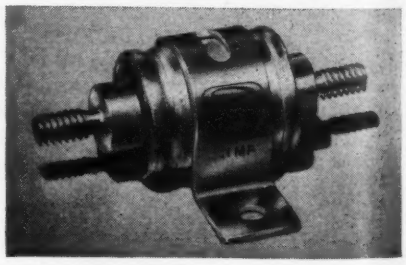
Designed to cut off machines or appliances at any predetermined temperature and remain inoperative until reset, the mica insulated Type RM thermal cut-out switch is pile constructed and corrosion protected. It can be reset by pushing a fibre button. The unit is rated at 1500 watts, 110-120 volts, ac and operates at temperature ranges of 0-150, 0-300, and 0-700°F. Two mounting holes with 5/16 in. centers are provided.—*George Ulanet Co., 413-415 Market St., Newark 5, N. J.*



SUB-MINIATURE THYRATRON

(Use Inquiry Card, Mentioning No. 123)

Designed specifically for intermittent and amateur service the RK61 sub-miniature thyratron tube is especially efficient for remote control circuits in applications requiring ultra-economy of space, weight, and battery drain. Similar in characteristics to the RK62 the tube is intended for use as a self-quenching super-regenerative detector for operating a high resistance relay in the anode circuit. The RK61 draws a filament current of .05 amps. at 1.4 volts and operates with an anode voltage of 30 to 45 volts. No signal plate current is 1 to 1.5 ma, which drops to .1 to .5 ma in the presence of a signal, with a relay resistance of 5,000 to 10,000 ohms in the plate circuit.—*Special Tube Section, Raytheon Mfg. Co., Newton, Mass.*



HIGH CURRENT CAPACITORS

(Use Inquiry Card, Mentioning No. 124)

Originally developed for wartime applications in attenuating radio interference from motors and generators these small, light-weight 3-terminal network filter capacitors are capable of continuous use at currents up to 100 amps with line voltages up to 250 volts ac. The capacitors are available in values to 0.75 mfd. They are hermetically sealed and furnished in corrosion-resistant metal housings.—*Solar Mfg. Corp., 285 Madison Ave., New York 17, N. Y.*

(*Continued on page* 123)

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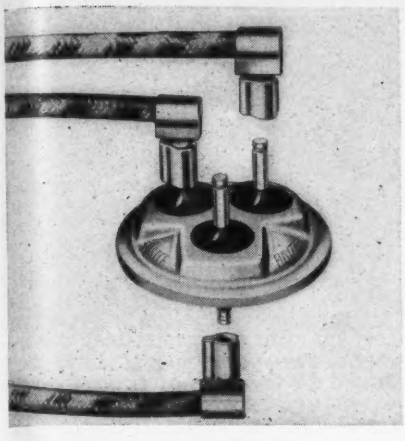


HERMETIC TERMINALS

(Use Inquiry Card, Mentioning No. 125)

Having been used successfully in meters, relays, rectifiers, capacitors, etc., the Fusite hermetic terminals have now been adapted for use in the refrigeration industry. The #353-MC refrigerator terminal can be welded into the compressor housing in 1/12 second and replaces 33 parts formerly used in hermetically sealed refrigerator compressors. In contrast to phenolic and similar materials the terminal does not deteriorate over a period of years. Illustration shows the terminal with mechanical connectors as used in refrigerators and high pressure applications.—*Cincinnati Electric Products Co., Cincinnati 12, Ohio.*

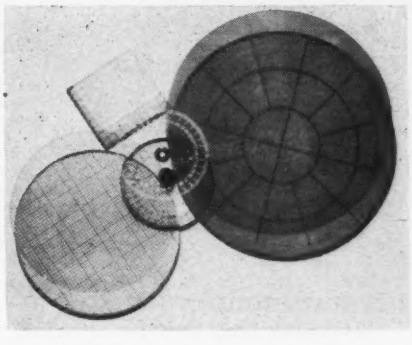
FLASHING PILOT LIGHT

(Use Inquiry Card, Mentioning No. 126)

Suitable for any circuit requiring a visual indicator this new pilot light incorporates a self-timing flasher which causes the light to blink at a rate of 60 to 80 times per minute. This flashing action is produced by a sealed, glass enclosed thermal unit of the hot wire type which provides snap action "make" and "break." The entire assembly including timer is 3½ in. long with a flange diameter of 1¼ in. It may be operated on dc up to 32 volts, and on ac, with an external resistor of 500 ohms, at 125 volts. Current consumption is 200 ma.—*Engineering Associates, 380 Main St., East Orange, N. J.*

CONDUCTIVITY DATA

A complete presentation of basic conductivity data in a form directly usable in laboratory and industrial applications has been made available by *Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*



PRECISION-ENGRAVED DIALS

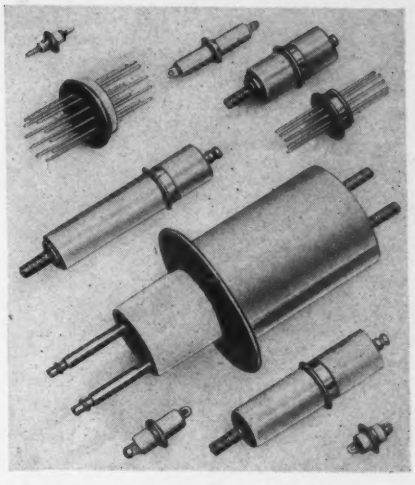
(Use Inquiry Card, Mentioning No. 127)

Made of plastic, metal, or glass, these precision-engraved dials and scales are manufactured on automatic machinery at cost below that of units produced by conventional pantograph engraving and have an accuracy to satisfy high requirements. As many as 6,400 radial graduations accurate to 2 minutes in 360 degrees can be engraved on circular dials up to 20 in. diameter. Straight lines can be engraved up to 15 ft. with no deviation; cross-section engraving as fine as 500 lines per in. is possible, with heavier lines being provided at desired intervals.—*American Precision Dial Co., 93 Massachusetts Ave., Boston* 15, Mass.

WIRE-WOUND RESISTORS

(Use Inquiry Card, Mentioning No. 128)

Offering a higher space-power ratio than standard tubular types, the type FRW flat wire wound resistors are designed especially for assembly in stacks and gangs. Two different coatings are available to protect the resistors against high temperature or for extreme climatic conditions. The resistance units can be supplied in values from 0.5 to 100,000 ohms depending on desired wire diameter and power rating.—*International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.*



SEALED STEATITE BUSHINGS

(Use Inquiry Card, Mentioning No. 129)

Permanent hermetic sealing capable of withstanding unusually severe mechanical and thermal shocks is provided for the Sealex line of bushings which are suitable for most industrial and electronic applications. An air pressure test of 50 psi is applied to each bushing. Individual leads or multiple headers up to 16 leads are available in sizes from 0.5 to 20 amps and flashover voltage ratings from 2,000 to 40,000. The units have a loss factor of .7% at 1000 kc and are suittable for a temperature range from 55 to 200° C.—*General Ceramics and Steatite Corp., Keasbey, N. J.*

100 KC CRYSTAL

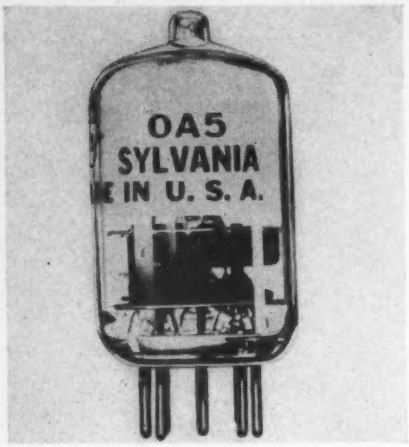
(Use Inquiry Card, Mentioning No. 130)

Designed for use in building a secondary frequency standard, this 100 kc crystal has low drift at normal operating temperatures and is rugged enough to withstand substantial vibration without change in frequency. The holder is sealed against moisture and dust. Standard ¾ pin spacing is used. An oscillator circuit diagram is supplied with each crystal.—*The James Knights Co., Sandwich, Ill.*

SILVER BRAZING ALLOYS

Two new silver brazing alloys with lower silver content have been developed by *Handy & Harman, 82 Fulton St., New York* 7. Easy-Flo 45 is a 45% silver alloy. Easy-Flow 35 (35% silver) is free flowing at a low temperature.

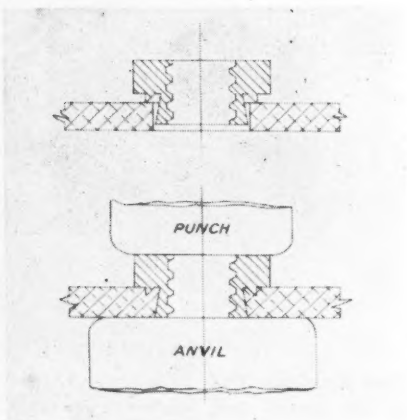
(*Continued on page* 124)



MINIATURE RELAY TUBE

(Use Inquiry Card, Mentioning No. 131)

Efficient for electronic photoflash and similar applications where manual trip shutter synchronizing or photocell switching is used, the type OA5 miniature cold cathode relay tube reduces firing delay from 100 to 1 microsecond, has positive-pulse low trigger grid current and stable triggering characteristics throughout life. A plate voltage of 750, a trigger grid bias of +90, and a pulse of 85 volts is a typical operating condition. The tube measures 1⅝ in. overall and 11/16 in diameter.—*Sylvania Electric Products, Inc.*, 500 *Fifth Ave., New York* 18.



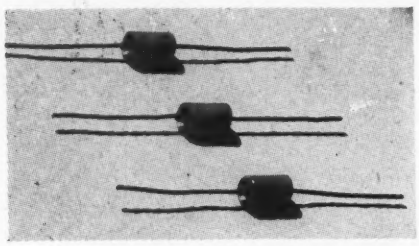
SELF-CLINCHING FASTENER

(Use Inquiry Card, Mentioning No. 132)

Intended for thin sheets of brass, aluminum, copper and plastics the PEM self-clinching fastener provides a load-carrying steel screw thread, and requires no special tools for clinching several fasteners in one operation. Shank length of the fastener can be less than the thickness of the sheet, the reverse side of which remains flush. The self-clinching design of the fastener provides a positive lock which prevents it from rotating even in very thin sheets. It is available in sizes 2-56, 4-40, 6-32, 8-32, 10-32, and 10-24.—*Penn Engineering & Manufacturing Corp., Doylestown, Pa.*

ANNOUNCEMENT

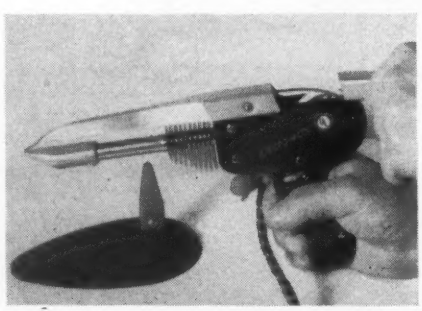
For the convenience of readers, all descriptions of new products have been assigned IDENTIFYING NUMBERS. For further information, please use the Prepaid Inquiry Card appearing at page 112 in this issue, and *Identify the product by the number assigned to it.*



CRYSTAL DIODE

(Use Inquiry Card, Mentioning No. 133)

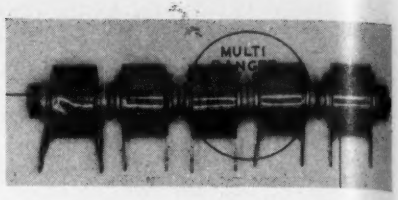
Designed to serve as rectifier, modulator, detector, or voltage regulator in radio and television applications, this germanium crystal diode has a safe forward current of 0.5 amps. and a safe back voltage of 60 volts. The diode consists of a micro-sharp platinum wire in point-to-plane contact with the face of a specially processed germanium crystal. The unit provides an interelectrode capacitance of approx. .2 mmfd and has a life performance of at least 3000 hours. It has a body length of 23/64 in. and a diameter of 7/32 in.—*Specialty Div., G-E Electronics Dept., Wolf Street Plant, Syracuse, N. Y.*



SELF-FEEDING SOLDERING IRON

(Use Inquiry Card, Mentioning No. 134)

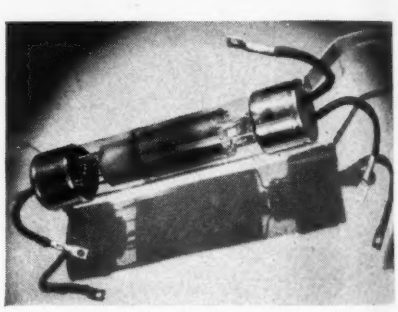
By freeing one hand of the operator the "Eject-O-Matic" automatic self-feeding soldering iron reduces fatigue and speeds production. A spool of cored solder fits into the molded phenolic pistol grip handle and is automatically fed to the tip by pulling a trigger. A micrometer adjusting wheel regulates the amount of solder fed by each pull of the trigger. A tool rest is supplied with the unit.—*Multi-Products Tool Co.*, 123 *Sussex Ave., Newark, N. J.*



METER RESISTOR KIT

(Use Inquiry Card, Mentioning No. 135)

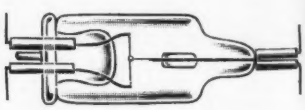
Containing all parts necessary for building a multi-test instrument, two resistor kits have been added to the line of precision wire wound resistors. Kit No. 1 contains half precision resistors and half matched pair resistors, while kit No. 2 is composed entirely of precision resistors. The parts are intended for the Marion 500 ohm, 400 microampere meter.—*Resistance Products Co.*, 714 *Race St., Harrisburg, Pa.*



HALF WAVE RECTIFIER TUBE

(Use Inquiry Card, Mentioning No. 136)

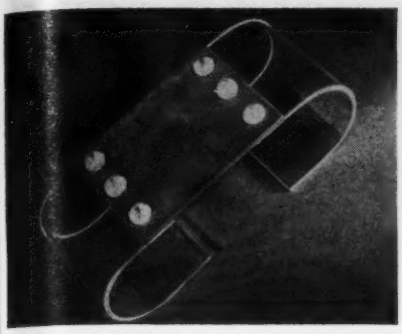
Designed to supply dc motors, magnets and batteries with up to 96 amperes dc at voltages varying from 24 to 600, the Type EL 16F Xenon gas filled half wave rectifier tube is intended for direct mounting on a panel without a socket. Operated at 2.5 volts filament voltage with an average plate current of 16 amps., the tube has a peak inverse voltage of 620 and an average arc drop of 7 volts. It can be used to power vibratory motors by means of special circuits.—*Electrons Inc.*, 127 *Sussex Ave., Newark* 4, *N. J.*



UHF VACUUM TERMOCOUPLES

(Use Inquiry Card, Mentioning No. 137)

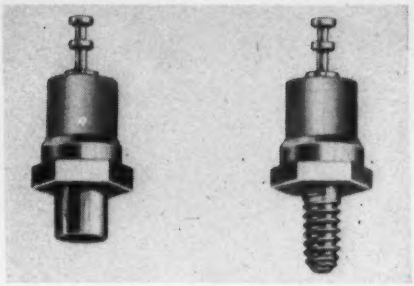
By locating the evacuating tip of this improved UHF vacuum thermocouple coaxial with the stem it becomes possible to mount it within coaxial cables or fittings in restricted space, thus providing improved shielding. The type U vacuum thermocouples find application in the measurement of current, voltage, and power at high and ultra-high frequencies.—*Field Electrical Instrument Co.*, 109 *East* 184 *St., New York* 53.



TRANSPARENT PLASTIC RIVETS

(Use Inquiry Card, Mentioning No. 138)

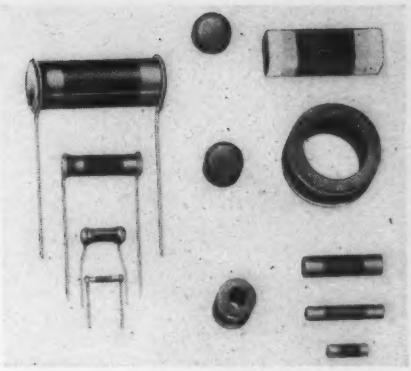
Since they will neither rust nor corrode, these transparent Plexiglas rivets are suited for use in electronic and high frequency apparatus for fastening light metals, rubber, or plastics. When used on fragile materials the acrylic fasteners can be clinched without shock by heating and expanding the rivets with air pressure. Supplied in a wide variety of colors and may be used as solid head or hollow shank rivets. Automatic and manual air and heater guns are available.—*Douglas Aircraft Co., Santa Monica, Cal.*



TERMINAL LUGS

(Use Inquiry Card, Mentioning No. 139)

In applications where high electrical potentials at rf frequencies are encountered over a broad humidity range, and where losses must be kept to a minimum these insulated midget terminal lugs are used on tie points of rf and high voltage leads. The lugs, furnished in rivet or stud type, are available with single or double midget lug, and have a voltage breakdown of approximately 6000 volts ac. The studs are made of cadmium-plated brass and phenolic insulators are securely fitted to avoid loosening under shock and vibration.—*Dept. 5, Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.*

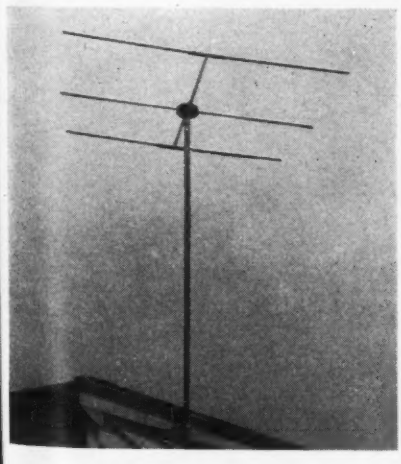


COMPENSATING RESISTANCES

(Use Inquiry Card, Mentioning No. 140)

Negative temperature coefficient resistance materials can be used successfully in compensating or neutralizing the positive coefficient of electrical circuit components, since in the range from 10 to 300 ohms at 25° C. an average decrease in resistance with rising temperature of 1 to 2% per degree centigrade is possible with the NTC resistance units. They are available in a variety of values and power ratings from 5 to 100,000 ohms in .5 to 3 watt sizes.—*Keystone Carbon Co., Inc., Saint Marys, Pa.*

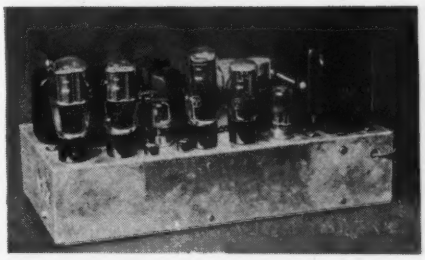
Communications Components



TELEVISION ANTENNA

(Use Inquiry Card, Mentioning No. 141)

Special high-gain television antennas have been designed to operate on most of the existing television channels now in use. Models are included for channels from two to six inclusive, and are adapted for use in locations where signal to noise ratio is low. The antenna is complete with all necessary parts, including an 8 ft. mast with mounting brackets. Entire assembly is designed to withstand high winds.—*The Workshop Associates, 66 Needham St., Newton Highlands 61, Mass.*



HIGH FIDELITY AMPLIFIERS

(Use Inquiry Card, Mentioning No. 142)

A series of amplifiers designed for use in high fidelity systems are built on a 17 in. chassis suitable for rack mounting. Included are a basic amplifier, model 10C without controls, intended for use with a separate tuner or preamplifier; model 10C2 is equipped with preamplifier and two tone controls, model 10C5 has a 2-channel mixer, and model 30A consists of preamplifier and mixer only. The basic amplifier has a frequency response from 20-20,000 cps within ±0.5 db and provides 34 watts output with less than 6% distortion. Gain is 55 db and humlevel is more than 70 db below full output. Basic input impedance is 0.5 megohm, with output impedances of 4, 6, 10, and 16 ohms being provided for. The units operate on 117 volts, 60 cycle, ac, and consume 116 watts.—*Brook Electronics Inc., 34 De Hart Pl., Elizabeth, N. J.*

PLASTIC MIKE

(Use Inquiry Card, Mentioning No. 143)

A plastic "colormike" for use in commercial broadcasting and entertainment has recently been developed. Available in five colors, red, blue, green, yellow and orange, it has a rugged case construction which allows free passage of sound from the outside to the inside of the microphone. It also has an unbreakable diaphragm and the Alnico V magnet. Variable impedance output permits a choice of 50, 200, 500 or 50,000 ohms for balanced line output.—*St. Louis Microphone Co., 2726-28 Brentwood Blvd., St. Louis 17, Mo.*

(*Continued on page 126*)

PACKAGED INTERCOM

(Use Inquiry Card, Mentioning No. 144)

Designed especially for small business offices and home use, this compact packaged intercommunication unit uses only one-half an amplifier, instead of having a complete audio amplifier in each master station. The calling unit utilizes the amplifier of each of the other units as well as its own. Each unit is a master station which transmits and receives, permitting conversation with any other units in the system. In a system of six units, two separate two-way conversations can be carried on simultaneously, while the rest of the system is open for paging. — *Dalmo Victor, Inc., San Carlos, Calif.*

NEW LAB EQUIPMENT
SEE PAGE 106

MODULATION METER

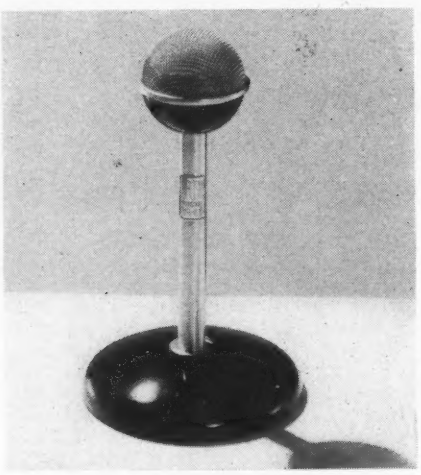
(Use Inquiry Card, Mentioning No. 145)

Designed primarily for amateur use in the phone bands between 3.5 and 54 mc, Type X-7018 modulation meter can also be used for forestry, police, emergency and other services which operate with AM transmitters. By application of the germanium crystal diode type 1N34 it was possible to eliminate vacuum tubes, batteries, and ac line power. The compact instrument permits direct reading of modulation percentage of sine-wave- or voice-modulated carriers, and also gives indication of carrier shift. It measures 4 in. wide, 4 in. high, 4¼ in. deep, and weighs less than 2½ lb.—*Sylvania Electric Products Inc., 500 Fifth Ave., New York 18, N. Y.*

TRANSMITTER-RECEIVER

(Use Inquiry Card, Mentioning No. 146)

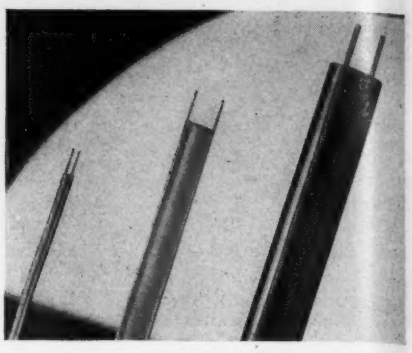
First exhibited at the National Aircraft Show at Cleveland, this VHF transmitter-receiver combination for commercial and private aircraft is characterized by light weight—17 lbs 9 oz—and small dimensions. The five-watt transmitter, model VHT, is designed for instrument board mounting and covers the range of fixed channels from 121.5 to 122.9 mc on six preset frequencies. The receiver Model VHR, is continuously tunable in the range from 108 to 124 mc and has a sensitivity of 4 microvolts per meter for a 4:1 signal-to-noise ratio. A single amplifier supplies power for transmitter and receiver. *Lear, Inc., Grand Rapids, Mich.*



CRYSTAL MIKE WITH STAND

(Use Inquiry Card, Mentioning No. 147)

Using the newly developed Acousticel incorporating bronze damping, the BA-106 crystal microphone provides essentially flat response from 40 to 6,000 cps with an output of 50 db below 1 volt dyne/cm² open circuit. The Acousticel microphone is the high impedance type and is supplied complete with 8 ft. cable, plug, and removable base for use as desk-type or hand-mike.—*The Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio.*

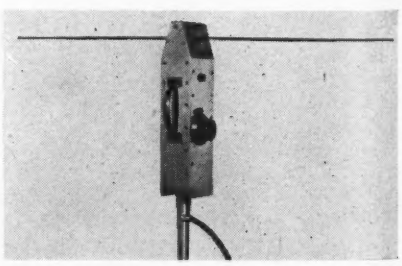


TWIN CONDUCTOR WIRE

(Use Inquiry Card, Mentioning No. 148)

A complete line of weather resisting low loss, twin conductor lead-in transmission wires has been brought out for a wide variety of applications in television, FM, amature radio, and home receiver installations. The lines are available with 100 ohms characteristic impedance for home receivers, 200 ohms for special high voltage transmitting or receiving equipment, and with 300 ohms impedance for television and FM lead-in, or for use with folded dipoles. The lead-in cables, insulated with solid polyethylene, resist acids, alkalies, oils, and water, and will not age in sunlight. — *Federal Telephone and Radio Corp., Newark, N. J.*

NEW DESIGN PARTS
SEE PAGE 110



PICKUP CONVERTER UNIT

(Use Inquiry Card, Mentioning No. 149)

Designed to extend the usefulness of low frequency noise and field strength meters into frequencies used for FM and television the Model 63-A Pickup converter unit may also be used as the tuning element in combinations with wideband metering units. The device picks up television signals in the range from 44 to 88 mc, amplifies them, and converts them to an if frequency of 10.7 mc which is fed to the metering unit. In calibrating the combination of pickup and metering unit a signal generator replaces the dipole antenna. Measurements of conducted noise and magnetic or induction fields can also be made by using probes and coils in place of the dipole. The unit may be operated from a battery pack for portable use, or an ac power pack.—*Ferris Instrument Co., Boonton, N. J.*

(*Continued on page* 128)

The Rauland *VISITRON* 10FP4/R6025

. . . the NEW Picture Tube with Unprecedented Brilliance

No Ion Trap Required

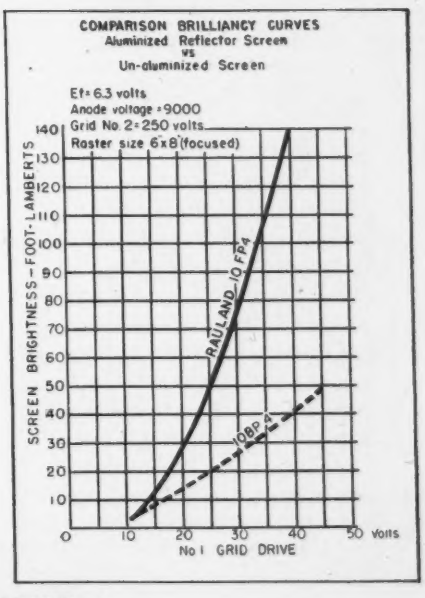
Virtually Flat Face

Direct Viewing

NEW!
ALUMINIZED REFLECTOR-SCREEN

Doubles the Brilliance
Highlight: 75 Foot Lamberts (avge.)
Contrast Range: Over 100 to 1
No Ion Spot—No Cathode Glow

Specifications of the Rauland Visitron 10FP4/R6025	
Heater Voltage	6.3 A.C. or D.C.
Focusing Method	Electromagnetic
Deflection	Electromagnetic
Deflection Angle	50 Degrees
Screen	Phosphor P4 Aluminized Reflector
Bulb Diameter (Max.)	10⅝" at screen end
Length	17⅜" ± ⅜"
Base	Small Shell Duodecal 7 Pin
Anode Terminal	Cavity
Anode Volts (Max.)	13,000
Anode Volts (Operating)	9,000
External Coating (Optional): 500 mmf.	



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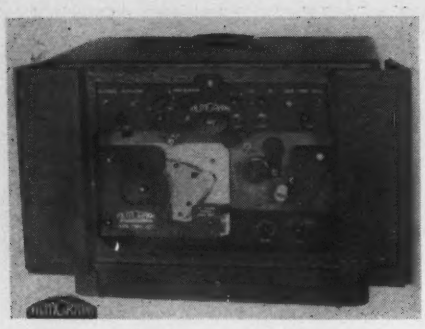
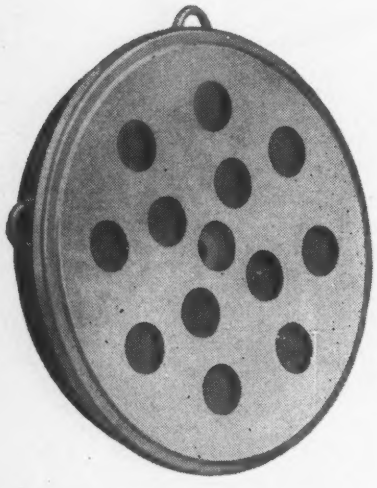


TELEPHONE RECORDER

(Use Inquiry Card, Mentioning No. 150)

Two- or multiple-way telephone recordings can be made on thin safety film at a cost of 5c per hour with the Telemike telephone induction interceptor in conjunction with the Filmgraph recorder-reproducer. The Telemike, measuring 1 in. square by ¼ in. thick and weighing approx. 2 oz., requires no physical contact with the telephone and picks up both sides of a conversation for loudspeaker listening or recording purposes. The Filmgraph models HM, HK, and CMT, will start and stop recording automatically in accordance with voice modulations received by the microphone. Continuous recordings up to 11 hours may be made of telephone conversations, conferences, lectures, etc.—*Miles Reproducer Co., Dept. EI, 812 Broadway, New York* 3.



HEARING AID MIKE

(Use Inquiry Card, Mentioning No. 151)

This ultra sensitive hearing aid microphone has a guard grille which prevents damage to the diaphragm during the assembly of the microphone in the hearing aid, etc. It is only 15/64 in. thick, including the grille. Designated as model HA-30, it measures 1⅜ in. over the flange and 1¼ in. in body diameter. The mike is rugged, since it has a diabow crystal element, in which the crystal itself is armored with two metal actuating units.—*Tibbetts Industries, Inc., Camden, Me.*

ANNOUNCEMENT

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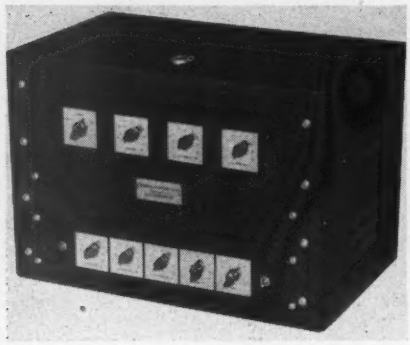


HIGH POWER AMPLIFIERS

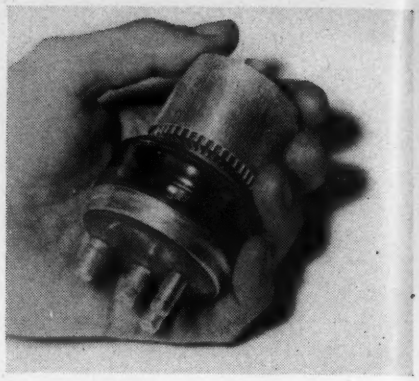
(Use Inquiry Card, Mentioning No. 152)

Designed especially for use in churches these two amplifiers consist of a 50-watt unit for driving two exponential projectors, and a 100-watt unit for driving four projectors. They are provided with two microphone channels, a phono channel, a base and treble equalizer. The output section has a "Tower" on-off switch, a channel for 1 to 10 hearing aids, and two output channels for indoor speakers with volume control for each. —*Francis J. Rybak & Co.,* 4131 *White Plains Rd., New York* 66.

MULTIPLE POLE RELAY

(Use Inquiry Card, Mentioning No. 153)

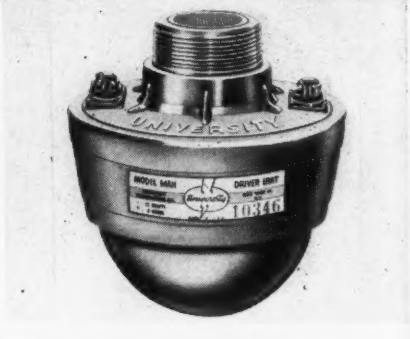
Designed for industrial and communication applications, R-B-M Series No. 98330 midget ac multiple pole relay is available for standard voltages from 1½ to 220 volts for 60 cycle operation. Contacts can be supplied to 4 poles, normally-open, normally-closed, or double-break with a rating of 3 amps. at 24 volts ac. The relay is also available in single pole, normally-open, double-break contact with 10 amps. rating at 115 volts ac.—*R-B-M Div., Essex Wire Corp., Logansport, Ind.*



HIGH POWER TETRODE

(Use Inquiry Card, Mentioning No. 154)

By compact design and an unique lead arrangement the Eimac type 4X500A power tetrode may be used in cavity circuits or in pin type sockets at maximum ratings up to 110 mc. The tube is rated at 500 watts plate dissipation and requires forced air cooling for its external anode. Low grid drive, controlled grid emission, high power gain, and stability are some of the characteristics of this tetrode. —*Eitel-McCullough, Inc., San Bruno, Calif.*



AUDIO DRIVER UNIT

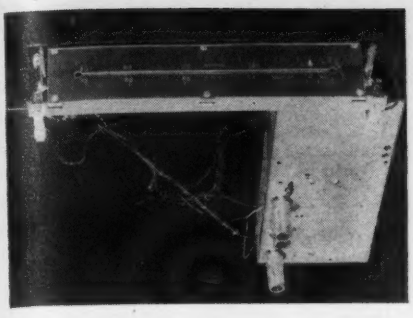
(Use Inquiry Card, Mentioning No. 155)

Capable of continuously handling up to 12 watts audio power, this new breakdown-proof driver unit is constructed of an Alnico V permanent magnet and a one-piece phenolic diaphragm, which is immune to extremes of temperature and corrosion. The voice coil is wound on duralumin band for maximum heat dissipation. The unit has a frequency range from 100 to 6,000 cycles and an impedance of 8 ohms. It has a diameter of 3½ in., height 3 in., and weighs 2¼ lbs. —*University Loudspeakers, Inc.,* 225 *Varick St., New York* 14, *N. Y.*

MICROPHONE STAND

(Use Inquiry Card, Mentioning No. 156)

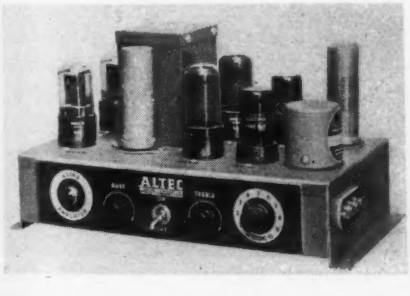
Guaranteed not to rust, this triple-plated copper, nickel and chrome microphone stand has a height range of 30 to 60 in. The heavy cast iron base has non-skid rubber pads. A newly designed quick-grip locking nut is guaranteed not to slip.—*Snyder Mfg. Co.,* 22*nd and Ontario Sts., Philadelphia* 40, *Pa.*



INDUCTIVE TUNER

(Use Inquiry Card, Mentioning No. 157)

Covering all 13 television channels, FM, amateur, and aviation from 44 to 216 mc, the Dumont Imputuner, available in a motor-driven and a manual model, is designed to be used in place of the conventional tuning systems in television receivers. Both models have identical rf circuits and components, and operate from a low impedance 72 ohm unbalanced line in order to minimize noise over the wide range. Three tunable circuits are provided, two for bandpass, and one for the oscillator. Tuner gain is approximately 10, and image suppression ratio on all channels is 100 or better. Frequency-temperature stability is held within one kc per degree C from 20° to 80° C. A 22 in. scale length provides adequate bandspread.—*Allen B. Du Mont Labs., Passaic, N. J.*



AC-DC AMPLIFIER

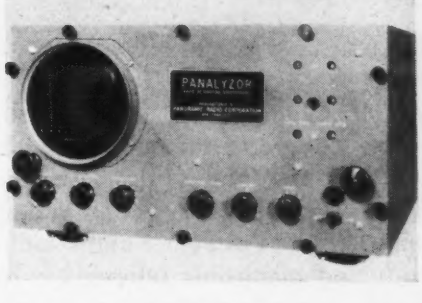
(Use Inquiry Card, Mentioning No. 158)

Designed primarily for use in commercial wired music systems and in home phonographs, the lightweight, ac-dc type A-319 amplifier will provide 4 watts output with a frequency characteristic flat within ±1 db from 40 to 15,000 cycles. Using a 6SJ7, a 6J5, two 25L6's, and two 25Z6's, the amplifier has a noise level of —28 db and an out put load impedance from 8 to 15 ohms. The unit is available in two models. The A-319A, supplied with wall cabinet, has a balanced bridging input transformer for bridging across 250 to 600 ohms lines, and provides a gain of 50 db. The A-319B, normally without wall cabinet, has high impedance input for crystal pickup use. It will provide 57 db gain from a high impedance input. Treble boost for the A-319A and bass boost for both models is continuously adjustable. The units are for operation on 105 to 125 volts, ac or dc.—*Altec Lansing Corp., 250 W. 57th St., New York 19.*

DYNAMIC MICROPHONES

(Use Inquiry Card, Mentioning No. 159)

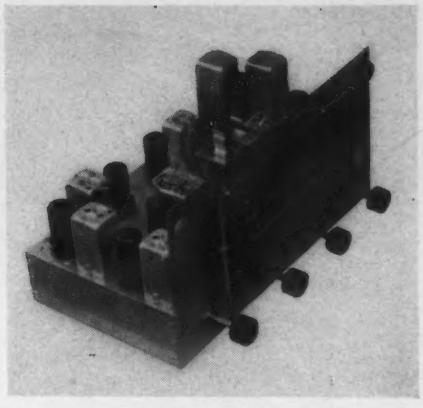
Designed as low-cost utility microphones for public address, paging systems, and similar installations, these two new crystal and dynamic microphones have the same cast metal case with a 15° fixed tilt. Frequency response is substantially flat from 50-8,000 cps, and polar pattern is non-directional at low frequencies, becoming directional at higher frequencies. Model 610 dynamic uses an acoustalloy diaphragm to withstand shock, humidity and high temperatures. Output level is — 53 db; it is available in high impedance—50, 250, or 500 ohm types. Model Q10 crystal microphone has an output level of —48 db and is of the high impedance type.—*Electro-Voice, Inc., Buchanan, Mich.*



PANORAMIC RECEPTION

(Use Inquiry Card, Mentioning No. 160)

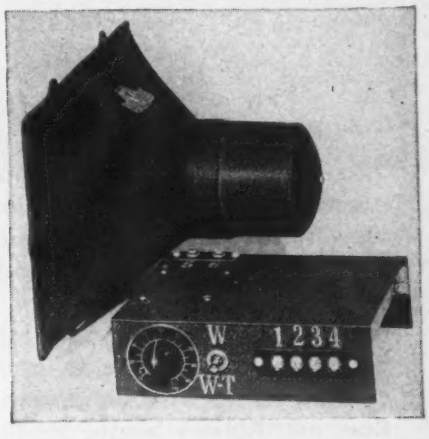
Permitting continuous visual observation of all signals present within a frequency band of adjustable width in any portion of the frequency spectrum, the Model SB-6 Panalyzor can be supplemented with a signal generator or separate oscillator capable of generating the required frequency. A 5 in. CR-tube is used for observation. Three versions of the unit are available having adjustable sweepwidth up to 10,000, 15,000 and 20,000 kc respectively. The resolution at maximum sweep is 75, 85, and 100 kc respectively. Provisions are made for dual signal input of the observed signal and the generator signal.—*Panoramic Radio Corp., 242-250 W. 55 St., New York 19, N.Y.*



FM-AM TUNER

(Use Inquiry Card, Mentioning No. 161)

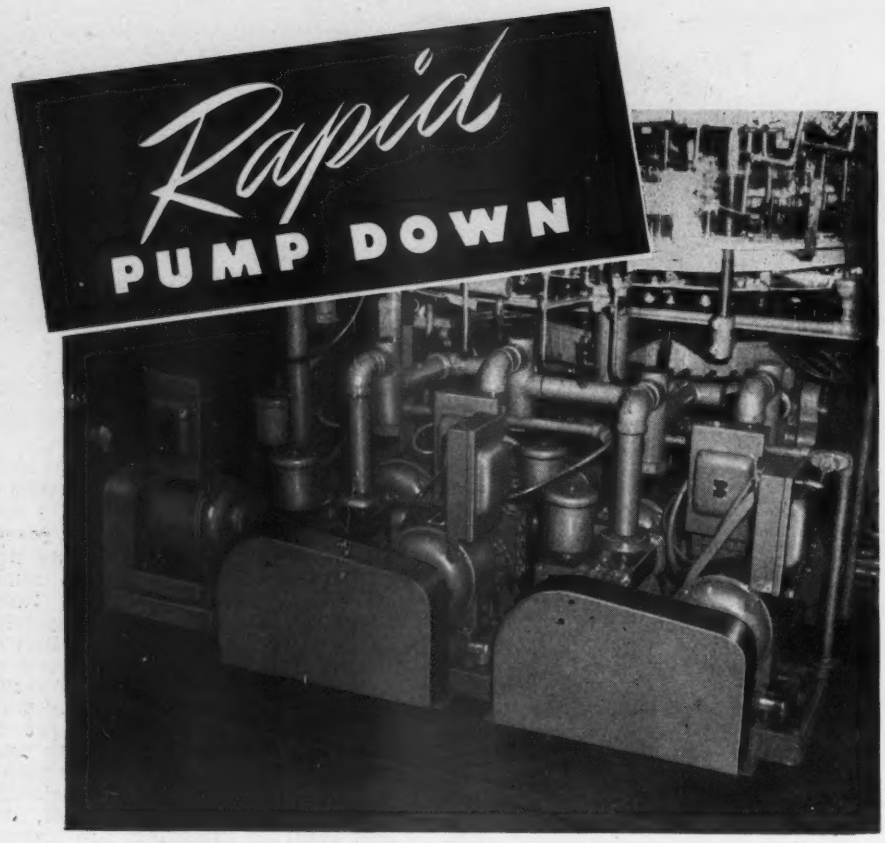
Designed for high-fidelity reception in the new FM band as well as the standard broadcast band, the Model RJ-12 FM-AM tuner uses separate RF and IF systems for both bands, the RF section of the FM band being composed of miniature tubes. FM tuning range extends from 87 to 109 mc and on the broadcast band from 530 to 1650 kc. Cascade limiters are used in the Armstrong circuit for maximum noise rejection. Sensitivity on broadcast is one microvolt, and less than 15 microvolt are needed for complete limiting on FM. The FM antenna also serves AM, the antenna input being 300 ohms. The unit can be supplied with or without separate power supply. It is for 115 volt, 60 cycle, ac operation. —*Browning Laboratories, Inc., Winchester, Mass.*



"TWEETER" SPEAKER

(Use Inquiry Card, Mentioning No. 162)

Made specifically for efficient high frequency reproduction and wide angle distribution this "tweeter" loudspeaker with integral dividing network may be used with any "woofer" in a suitable baffle by connecting to the cross-over terminals. Model HF-1 has a power capacity of 20 watts with the "woofer" connected and a high frequency response within ± 6db up to 14,000 cycles. Spatial distribution is 80° horizontal and 40° vertical. Impedance will match 8 ohm "woofer" and amplifier output.—*Atlas Sound Corp., 1447 39 St., Brooklyn, N. Y.*



KINNEY

HIGH VACUUM PUMPS

MAINTAIN LOW ABSOLUTE PRESSURES FOR MODERN PROCESSING

This group of Kinney Compound Vacuum Pumps can exhaust electronic tubes faster than operators can load the machine. The view shows only 5 of the more than 700 Kinney High Vacuum Pumps serving Sylvania Products, Inc. The reliability, compactness and high pumping speed of Kinney High Vacuum Pumps make them the choice—not only for producing electronic tubes—but for countless applications in other fields, including sintering metals, coating lenses, vacuum drying, producing drugs, cyclotron evacuation, etc. Kinney Single Stage Vacuum Pumps produce and maintain low absolute pressures to 10 microns; Compound Vacuum Pumps to 0.5 micron.

Write for Bulletin V45.

KINNEY MANUFACTURING COMPANY

3568 WASHINGTON ST., BOSTON 30, MASS.

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Horrocks, Roxburgh Pty, Ltd., Melbourne, C. I. Australia

W. S. Thomas & Taylor Pty, Ltd., Johannesburg, Union of South Africa

We also manufacture Liquid Pumps, Clutches and Bituminous Distributors.

DuMont Demonstrates Color Television

A new color television system designated the "trichromoscope" was demonstrated middle of December by the Allen B. DuMont Laboratories to the FCC. It uses a three gun cathode ray tube each gun modulated with its own color signal, and projected at any instant toward the same point on a special screen.

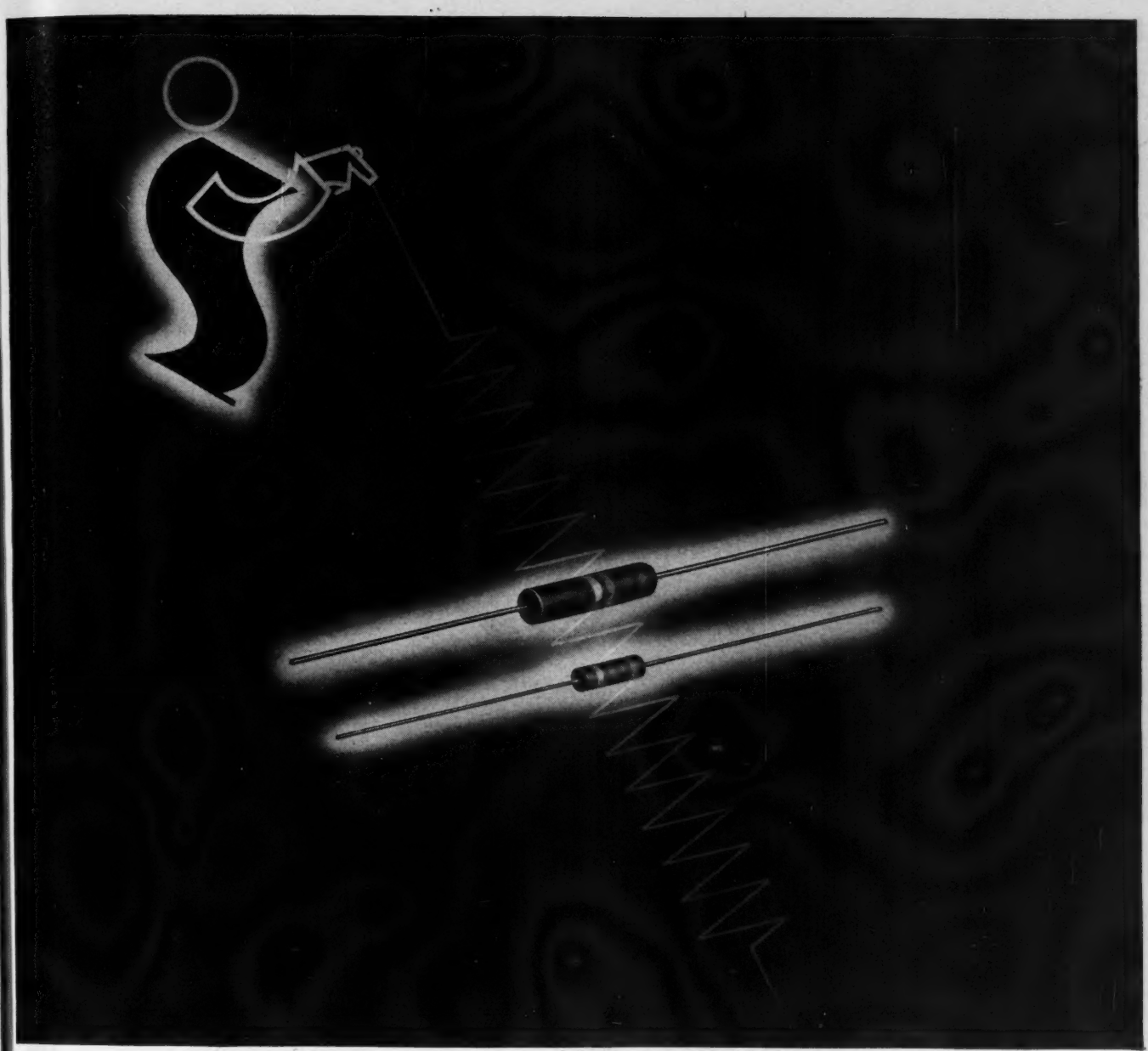
On this type of screen the fluorescent surface is coated with microscopic triangular prisms or pyramids. These crystal pyramids are all precisely oriented and compounded in a unique manner. Particular surface areas of each of these multitudinous "trilons" are coated with a primary color phosphor, so that the series of prismatic facets (facing the particular gun which handles one of the color channels) glows red, green or blue when electrons strike it.

The new device, was stated to operate equally well with either "continuous" scanning or "sequential" scanning, or with ordinary black-and-white images. This means that it is a full "electronic color" system. In case the "sequential" systems were to be selected ultimately, this system would therefore operate without the need for rotating discs in the receivers.

The color system was not demonstrated in full at this time however, nor was a complete screen with finely divided color sensitive elements shown. Dr. T. T. Goldsmith of the DuMont Laboratories who described the system, demonstrated the principles involved on a large scale. He estimated that the method would provide at least fifteen times the screen brilliance of any other home color television reception system, or even more if used with systems that project all three primary colors onto the screen simultaneously by use of separate channels. A more complete experimental program is being prepared and the system and its characteristics will be described in greater detail in a later issue.

Illinois Condenser Expands

Illinois Condenser Co., Chicago, has occupied its new plant and is now in full operation. The new address is 1616 N. Throop St.



Fixed RESISTORS

You have seen resistor pictures before. Lots of them! Maybe you have even raised your eyebrows over diverse claims as to hair-splitting points of difference about resistor quality.

All we have to say is this:

Stackpole has long since proved its ability to make resistors to exceptionally high quality standards.

We don't claim any unsurpassed abilities or facilities for doing the impossible. We *do* claim to be fully capable of meeting your resistor needs — and to have the type of organization with which it is a pleasure to deal.

If you use reasonable quantities of fixed resistors up to 1 watt or variable resistors to almost any specification, Stackpole will welcome the opportunity to cooperate.

Ask for Catalog RC-6 — Stackpole Fixed and Variable Resistors — Standard, High-Frequency, Sleeve and Screw Type Iron Cores — Line Slide and Rotary Action Switches.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

STACKPOLE

FIXED and VARIABLE RESISTORS—IRON CORES—SWITCHES

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MAKERS OF THOUSANDS OF RADIO AND ELECTRONIC PARTS
COMPLETE FACILITIES FOR FILLING YOUR "to specification" ORDERS
TREMENDOUS STOCKS OF QUALITY STANDARD PARTS

Insuline began to design, develop and produce quality radio parts for the industry a quarter of a century ago.

Today, Insuline produces one of the biggest lines of standard parts — everything from a small stamping to a giant transmitter cabinet—and occupies an enviable position as a to-your-specifications manufacturer.

You'll find quantity and quality, speed and precision, at Insuline. You'll find more complete details in Insuline's hot-off-the-press catalog. Write Dept. C-14 for your copy—now

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Corporation of America

INSULINE BUILDING · LONG ISLAND CITY, N. Y.

More than a quarter-century of Quality production

SPECTRUM GENERATOR FOR ACOUSTIC TESTS

(*Continued from page 43*)

Jones plugs and jacks which engage when the unit generator is slid into place in the rack.

Tests conducted with the complete oscillator assembly, dual mixer panel, and a commercial master amplifier resulted in distortion and difficulties in obtaining required signal strength for frequencies below 100 cps. These difficulties were traced directly to the amplifier, necessitating the design of an amplifier possessing a frequency response characteristic which would faithfully amplify frequencies from 40 cps or less to 20,000 cps. The writer designed an amplifier having a double push-pull, direct-coupled circuit which would meet the requirements of this special application.

Response Tests

Two amplifiers were constructed, one capable of providing up to 15 watts output for the speech spectrum, the other capable of providing up to 47 watts output for the high ambient noise spectrum. Both amplifiers were tested by determining their frequency response curves over a range of 20 cps to 20,000 cps. A listening test, by using the amplifiers to amplify music from high grade commercial recordings, also was made. Both tests proved that the performance of these amplifiers was better than required for this application.

It is estimated that the time saved with the new equipment for point-by-point frequency response tests is approximately 60% of that required for the previous method and equipments normally used for this test.

The time saved with the new equipment for frequency response tests performed under simulated ambient noise conditions is approximately 90% that required for the previous equipment and method. The former method required approximately two days for setting up and calibrating the test equipment, whereas the new method requires less than two hours for setting up and calibration.

PERMANENT MAGNETS MAY DO IT BETTER!

Now! we're ready to Demonstrate HYFLUX*

Magnetic Recording Tape with *full fidelity* performance

HYFLUX magnetic recording tape is a new "packaged energy" product of The Indiana Steel Products Company offering for the first time full, rich, high fidelity performance at moderate operational speeds. HYFLUX, the result of over a third of a century of experience in permanent magnet production augmented by independent research of the Battelle Memorial Research Institute, is a paper tape coated with fine high-energy magnetic particles with characteristics comparable to the well-known grades of Alnico. The simplicity of its design, its high fidelity performance, and the low cost materials used in fabrication provide HYFLUX tape with exceptional advantages for modern commercial recording.

Although The Indiana Steel Products Company will only produce HYFLUX Tape itself, the importance of developing a soundly engineered recorder for HYFLUX magnetic tape was recognized. The combined work of The Indiana Steel Products Company and the Physics Research Division of the Midwest Research Institute resulted in a single basic mechanism which incorporates outstanding new refinements in recording magnetics, electronics, mechanics, and acoustics. These engineering findings will be available to all recording machine manufacturers who are HYFLUX licensees. *Write today for additional information on the technical application of* HYFLUX *recording tape.*

* Reg. U. S. Pat. Off.

HYFLUX Magnetic Recording Tape Brings These New Advantages to the Field of Sound Recording

- High Fidelity Performance
- Low Operating Cost
- Compact . . . ½ hour recording on a single 8 MM reel.
- Flexible and Durable in Use
- Permits Precision Editing

★ THE INDIANA STEEL PRODUCTS COMPANY ★

PRODUCERS OF "PACKAGED ENERGY"

6 NORTH MICHIGAN AVENUE * CHICAGO 2, ILL.

SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

PLANTS { VALPARAISO, INDIANA
STAMFORD, CONN. (CINAUDAGRAPH DIV.)

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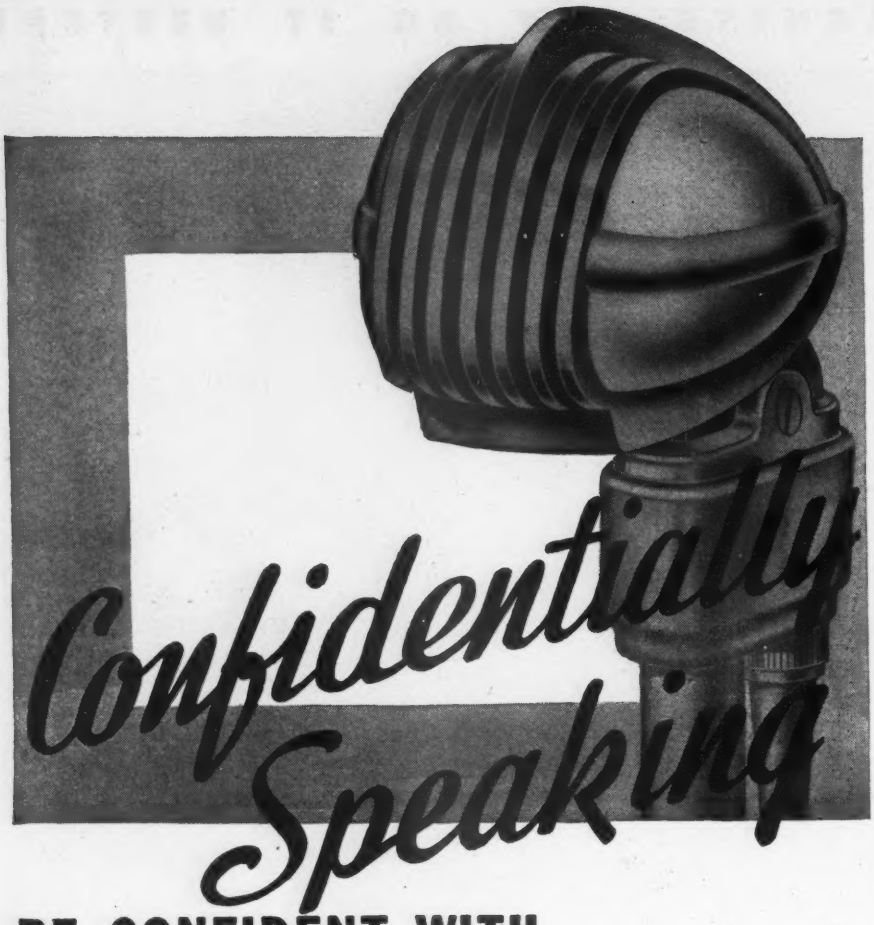


BE CONFIDENT WITH A MICROPHONE BY TURNER

Whether it's a general purpose unit for voice and music, or a unit for a specialized application you'll always be confident of accurate pickup and faithful reproduction when your microphone is a Turner. Turner Microphones are proving their superiority in design and manufacture to new users every day.

Illustrated is the Turner Model 33—a high fidelity all purpose microphone that combines high output with smooth response over a wide frequency range. Its matched acoustic design results in crisp, clear speech reproduction . . . music is full and round with tonal qualities faithfully retained. Furnished in a choice of high quality crystal or rugged dynamic circuits. It is recommended for studio recording, remote control broadcast, orchestra pickups, paging, dispatching and call systems, public address and communications work.

MODEL 33X CRYSTAL
Response: Flat within ±5db from 30-10,000 cycles.
Output Level: 52db below 1 volt/dyne/sq. cm.
Impedance: High impedance.
Crystal: High quality moisture sealed crystal.
Stand Coupler: Standard ⅝"—27 thread.
Cable: 20 ft. removable cable set.

MODEL 33 DYNAMIC
Response: Flat within ±5db from 40-10,000 cycles.
Output Level: 52db below 1 volt/dyne/sq. cm.
Impedance: 50 ohms/250 ohms/500 ohms/high impedance.
Magnetic circuit: Heavy duty dynamic cartridge.
Stand Coupler: Standard ⅝"—27 thread.
Cable: 20 ft. removable cable set.

THE TURNER COMPANY
905 17th Street N. E., Cedar Rapids, Iowa

Licensed under U. S. Patents of the American Telephone and Telegraph Company, and Western Electric Company, Incorporated. Crystals licensed under patents of the Brush Development Company.

TURN TO TURNER FOR THE FINEST IN ELECTRONIC EQUIPMENT

ELECTRONIC AIDS FOR PLANES

(*Continued from page* 41)

and short range radar sets, including GCA radars, to keep continuous surveillance of a plane from a departure airport until surveillance is accepted by an airport of destination.

Sperry Air Traffic Control System—A microwave system including instrument landing, omni-azimuth indications, distance indications and automatic approach control.

Airborne Radar Obstacle Detectors and Search Radar and Beacons—Radar technics with various types of scan are used on a plane to locate distance and direction of other airplanes and obstacles. Other uses are to map ground, find wind drift, etc. Beacons can be put on the ground. These give bright responses and can form a track. Sets such as the AN/APS 10 3 cm. installation can be used. Canadian as well U.S. proposals are involved.

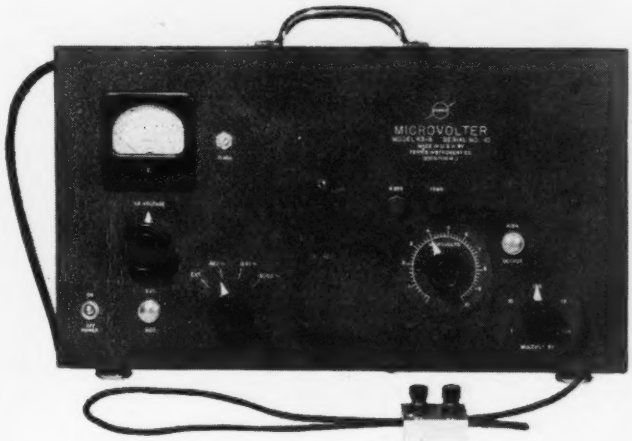
Air Traffic and Navigation Systems—This Federal Telephone and Radio system includes, in the air, two radar receivers, one transmitter, distance and azimuth converters, three omni-directional antennas, a decoder, coded response signal generator, command indicator, barometric and identification modulators. On the ground there are two radar transmitters, two receivers, two highly directional and two omni-directional antennas and a primary ground radar. Also included are an orientable directive antenna and two receivers. System operates at 3300 mc and 1000 mc. System provides pilot simple dial type indications of azimuth and distance to any selected ground station. Also provides ground with radar displays of all planes in area and means for identifying planes without speech.

Federal Navar, Navaglide and Navascreen Systems—These systems include ground radar, plane responder beacons with distance and azimuth meters. Navar provides eight functions as follows: (1) A ground PPI radar display; (2) addition of beacon responses from planes to a second PPI and an altitude layer blanking feature permitting observation by altitudes; (3) a selective PPI showing only planes with beacons turned to the

FERRIS *instruments*

The Name Ferris Is Well Known in the Radio Industry for Its Line of Standard Instruments

Not everyone realizes, however, that Ferris builds many special purpose instruments such as those shown here



for Aviation . . .

The Model 43-B microvolter crystal controlled oscillator multipliers, modulated amplifier 6.325 MC and 75 MC.

for Railroads . . .

The Model 22-E signal generator — a low frequency F.M. instrument 30 to 800 KC

If you have a special problem requiring instruments having out of the ordinary features possibly these or other similar units may help

Write to the

FERRIS INSTRUMENT CO.

110 CORNELIA ST. BOONTON, N. J.

FERRIS

Micah is Long-Lived . . .

Micah is long-lived. This perennial juvenile has drunk from the proverbial fountain of youth and eschews vitamin pills and glandular extracts. Gray-bearded old men remember him when *they* were still in swaddling clothes! It's youth! Youth! Youth!

And mica (without the "h") is long-lived, too. Motors and such may wear out, coils and wire may disintegrate, but mica marches on, unchanged by the years. Nothing else lasts as long, nothing else performs as well. There is no substitute for mica. And there is no substitute for *Macallen Mica!*

When You Think of MICA, Think of MACALLEN

THE MACALLEN COMPANY

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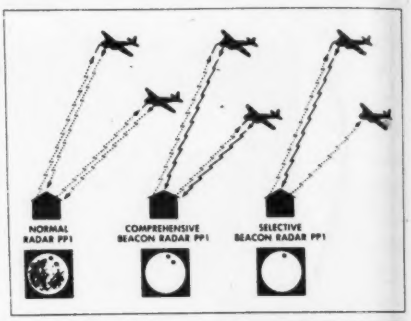
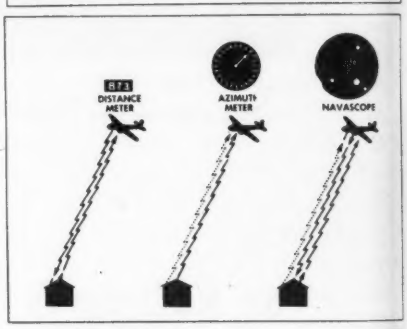
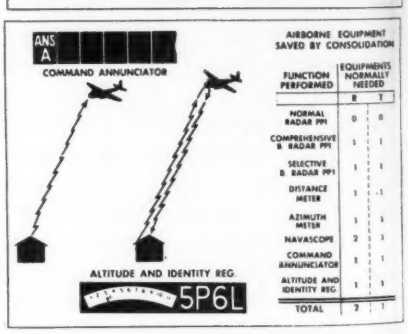
airport—i.e., eliminating casual and transient planes; (4) a distance meter in the plane; (5) an azimuth meter in the plane; (6) an airborne pictorial (PPI) scope display showing on a superimposed map planes in chosen altitudes, wind arrows, ground station; (7) a ground pick-out system whereby a plane is interrogated and gives a coded reply; (8) a ground command system causing a series of commands to appear on an annunciator in front of the pilot.







Federal Navar, Navaglide and Navascreen—Summary of the system's principal operating features

Navaglide is a microwave glide path system using time sharing to transmit up, down, left and right indications to a single meter in the cockpit.

Navascreen is a ground display and computing system for airport control. On a large screen all planes' positions would be projected, using colors for altitude identification.

Hazeltine Lanac System—A system based on challenger-response

Metal Tubing in Glass Houses

. . . must be as right as right can be!

The Superior Tube Company, Electronics Division, has spared nothing in its effort to bring to the Radio Tube Industry, through its highly specialized facilities, metal tubing in the form of cathodes, anode and grid cylinders, and all types of fabricated tubular parts. These products, used in all types of electron tubes, are the metallurgical and physical counterparts of your electronic expectations. • Material control standards, otherwise unattainable, are now realities. Superior's Electronics Laboratory has made possible far-reaching research and development of electronic tubing, through the study of materials, processes and controls. • Whatever your requirements in metal tubing for electron tubes, bring your problems to us. The Engineering Staff of Superior Electronics Division will welcome your inquiries and the privilege of working with you.

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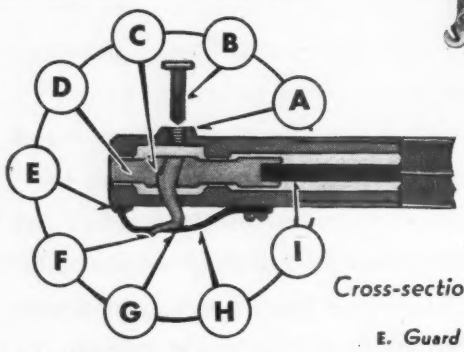
see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

USE of Astatic's new Nylon 1-J Crystal Pickup Cartridge in new installations, assures phonograph manufacturers that the quality of reproduction shall remain CONSTANT, regardless of needle replacements, during the life of the instrument. This cartridge employs a Nylon Chuck and matched, sapphire-tipped, knee-action, REPLACEABLE Nylon Needle. Because this Nylon Needle is matched to the cartridge, it is the only needle that can be used with it, and the quality of reproduction must, therefore, remain unalterable . . . always.

MODEL NYLON 1-J CARTRIDGE



Cross-section View of Cartridge

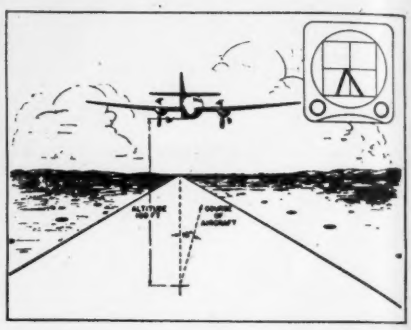
A. Ejector Screw Hole
B. 2-64 Ejector Screw
C. Needle Locating Fin
D. Tapered Nylon Chuck
E. Guard Height Adjusting Screw
F. Sapphire Playing Tip
G. Tapered Nylon Needle Knee
H. Needle Guard
I. Crystal Element

THE Astatic CORPORATION
ASTATIC
CONNEAUT, OHIO
IN CANADA: CANADIAN ASTATIC LTD., TORONTO, ONTARIO

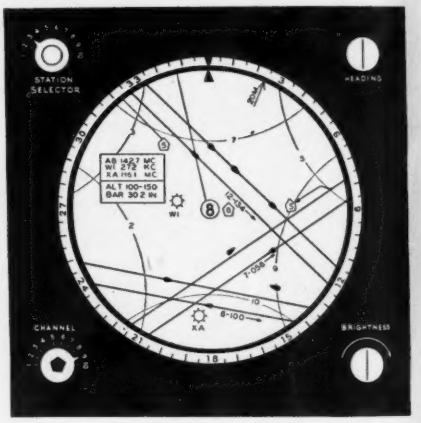
Astatic Crystal Devices Manufactured under Brush Development Co. patents.

technic plus barometric modulation for altitude separation.

Westinghouse System—Low powered radio transmitters outline landing strips, airfields, airways, etc. Airborne beacons are placed on each wing tip and in the tail of aircraft. A light airborne receiver includes scanning antenna with 5



Westinghouse system—Indication when aircraft is not headed directly up the landing runway



Teleran System (RCA)—Typical picture in plane

in. beam and cathode ray tube indicator. Operates in the 3, 10 or 60 cm bands. The outline transmitters appear on the scope as spots of light.

Teleran System (RCA)—A radar picture on a ground controller is televised to the airplane. A number of special features can be added to the ground picture quite readily. Different altitudes are handled by different television channels.

Hickok Eastern Service

Hickok Electrical Instrument Co., with headquarters in Cleveland, Ohio, has established an Eastern organization for the repair and servicing of its instruments. The service station is under the management of Kenneth E. Hughes and is located at 339 West 44th Street, New York City.

EBY TERMINAL STRIPS

TYPE TS-56

Screw Type. For applications where wires must be attached and detached quickly and conveniently at intervals. Supplied plain or marked to customers' specifications. Also available with Knurled Head screws.

Contacts—Brass, cadmium plated
Screws—Steel, cadmium plated
Plates—1/16" XP Phenolic sheet

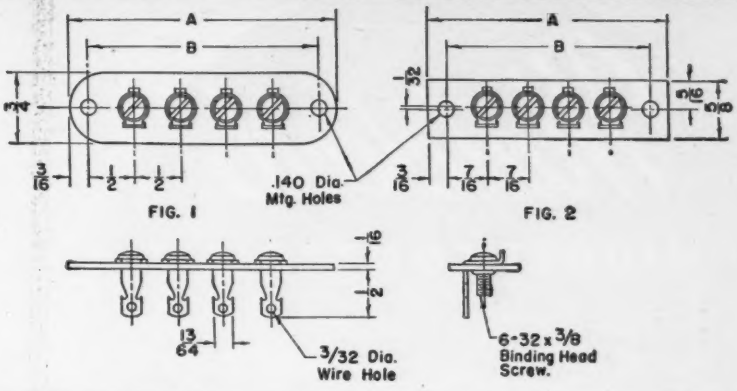
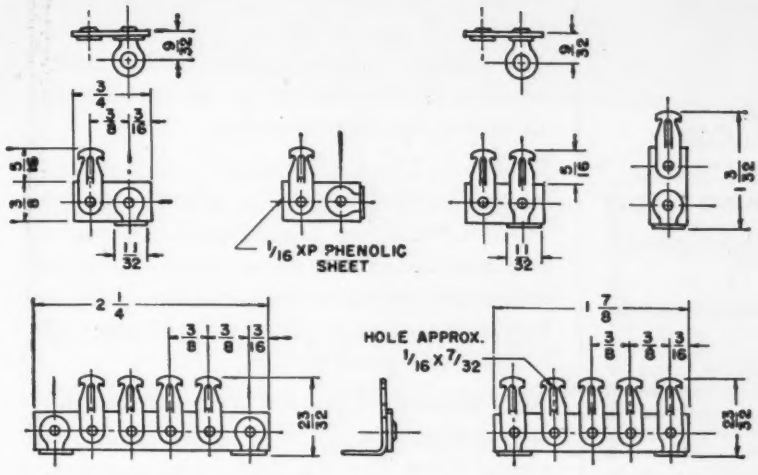
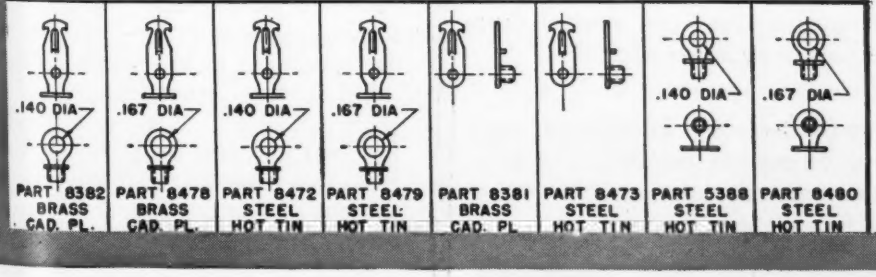


FIGURE NO.	CATALOG NO. BINDING HEAD SCREW	CATALOG NO. KNURLED HEAD SCREW	NO. OF TERMINALS	OVERALL LENGTH 'A'	MTG. HOLES CENTERS 'B'
1	8513	8523	1	1 3/8	1
1	8514	8524	2	1 7/8	1 1/2
1	8515	8525	3	2 3/8	2
1	8516	8526	4	2 7/8	2 1/2
1	8517	8527	5	3 3/8	3
1	8518	8528	6	3 7/8	3 1/2
1	8519	8529	7	4 3/8	4
1	8520	8530	8	4 7/8	4 1/2
1	8521	8531	9	5 3/8	5
1	8522	8532	10	5 7/8	5 1/2
2	8706	8711	1	1 1/4	7/8
2	8710	8712	2	1 11/16	1 5/16
2	8610	8713	3	2 1/8	1 3/4
2	8707	8714	4	2 9/16	2 3/16
2	8708	8715	5	3	2 5/8

TYPE TS-58

Tie Point. Used throughout industry for tying in a wide variety of components. Available in any combination of terminals or brackets as shown up to and including 14. Holes are spaced 3/8" apart with 3/16" between end holes and edge of board. Terminals available with elongated hole for threading or notched for wrap-around assembly. Plates are of XP Phenolic sheet.





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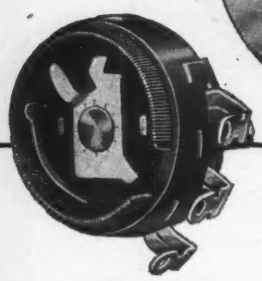

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WIRE-WOUND MIDGET

Smallest unit now available of that rating.

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Rated at 2 watts. 1 to 10,000 ohms.

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Matches Clarostat Type 37 midget composition-element control—in appearance, dimensions, rotation, switch.

* * *

Available with or without power switch.

* * *

Available in tandem assemblies—suitable combinations of wire-wound and composition-element controls.

* * *

Type 37 composition-element controls rated at ½ watt. 500 ohms to 5 megohms.

★ They look, measure and operate the same—these Clarostat wire-wound and composition-element midget controls. Fully interchangeable, mechanically. Can be made up in various tandem assemblies.

Clarostat Type 37 midget *composition-element* controls have been available for several years past. Their *stabilized* element has established new standards for accurate resistance values, exceptional immunity to humidity and other climatic conditions, and long trouble-proof service.

And now the Clarostat Type 43 midget *wire-wound* control is also available, to match Type 37—matched in appearance, dimensions, rotation, switch.

For neatness, compactness, convenience, trouble-free operation—just specify these Clarostat *matched midget controls.*

★ *Write for literature. Submit that resistance or control problem. Let us quote on your requirements.*

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Controls and Resistors

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

SIGNAL GENERATING UNITS

(*Continued from page* 54)

the mixer (28), while a 60-cycle negative pulse is applied to the grid of this tube. The output of the mixer consists of 15,750-cycle pulses except during the intervals of the 60-cycle pulses. The signal is applied to a clipper (47) which feeds common load resistor of the clipper stage (18).

The 60-cycle negative keying pulse referred to above, is generated in the "number of equalizing pulses multivibrator" (14) which is located on the pulse former chassis for mechanical symmetry and convenience. This multivibrator is synchronized by a pulse from the 60-cycle stage of the frequency divider chain and its output is fed to the clipper (15) which produces a negative keying pulse.

Generating Units

The third signal is also composed of 15,750-cycle pulses keyed by the 60-cycle signal from the "number of equalizing pulses" multivibrator, (14). The 15,750-cycle pulse is produced by the Notching Pulse Multivibrator (30) which is synchronized by a pulse from the delay line, if required. Delay circuits (21), (25) and (31) are selected points on the same multi-stage delay line having 32 taps. The two signals from (14) and (30) are mixed in (16), the output of which is applied to a two stage clipper (17), the second stage of which feeds the common load resistor of (18). This signal has the notching pulse present except during the 60-cycle keying interval.

The fourth signal is a complex one, consisting of groups of six 31,500-cycle pulses recurring at a 60-cycle rate. The 31,500-cycle pulses are generated in the vertical pulse multivibrator, synchronized by a pulse from the 31,500-cycle delay line (43) and (44) through a buffer, (45). It is necessary that the groups contain six complete vertical pulses, consequently the leading edge of the 60-cycle pulse must fall between adjacent 31,500-cycle pulses, and not during these pulses.

A negative pulse is obtained from the vertical pulse delay multivibrator (39) which is synchronized by the 60-cycle negative pulse from

Model 2450

ELECTRONIC TESTER

There's never been a tester like this!

Here's a tester with dual voltage regulation of the power supply DC output (positive and negative), with line variation from 90 to 130 volts. That means calibration that stays "on the nose"! That means *broader service* from a tester that looks as good as the vastly improved service it provides. And, together with its many other new features—including our Hi-Precision Resistor which outmodes older types—it means higher performance levels wherever a tester is needed. Detailed catalog sheets on request.

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- LOAD IMPEDANCE: 51 megohms on DC Volts.
- CIRCUIT LOADING: Low frequencies. Circuit loading equal to 8 megohms shunted by 35 mmfd. High frequency circuit loading equal to 8 megohms shunted by 5 mmfd.

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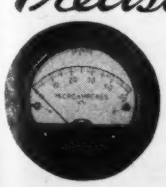

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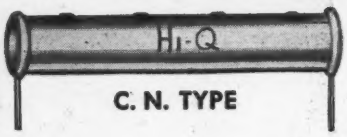
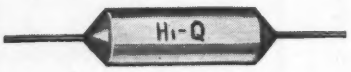


C. N. TYPE

S. I. TYPE
Durez Coated



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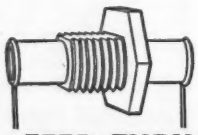
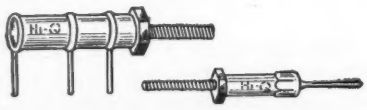
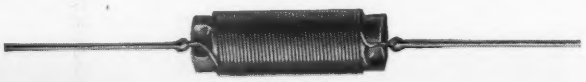




FEED THRU AND STAND-OFF CAPACITORS

WIRE WOUND RESISTORS

CHOKE COILS



Hi-Q ELECTRICAL REACTANCE CORPORATION
FRANKLINVILLE, N. Y.

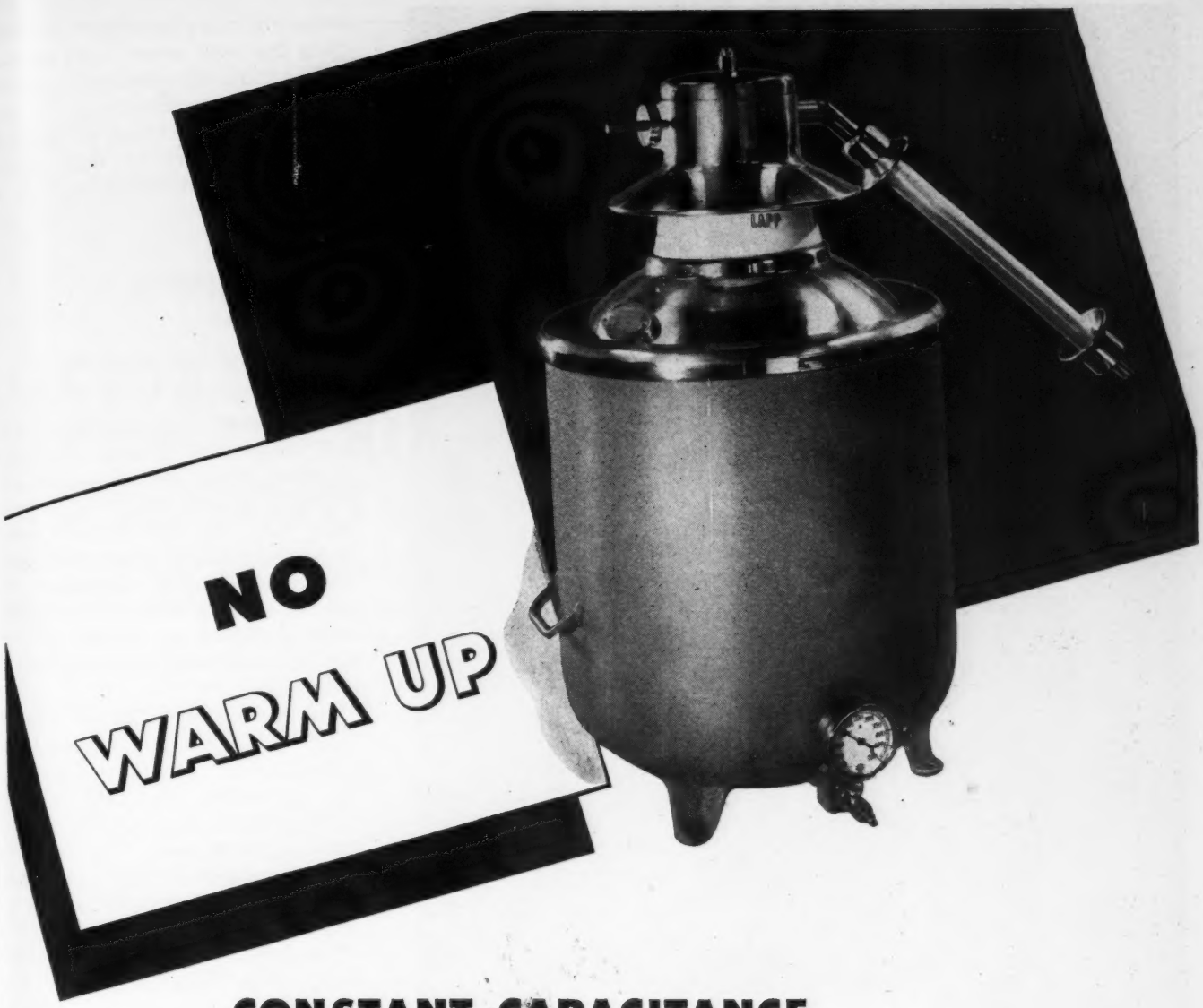
(13). This pulse is differentiated and applied to the number two control grid of the mixer (40), where the trailing edge of the pulse becomes a positive keying pulse. A narrow, 31,500-cycle pulse is applied to number one control grid of the mixer from the vertical pulse multivibrator (46) and appears on the plate as a group of negative 31,500-cycle pulses which occur during the interval of the 60-cycle keying pulse. The first of these pulses synchronizes the "number of vertical pulses" multivibrator (41).

RMA Sync Signals

The positive output of this multivibrator is applied to the number one grid of the mixer (42), while a wide positive 31,500-cycle pulse from (41) is applied the number two control grid. This latter pulse is obtained from the inverted form of the wave which was used to trigger (41) only at a particular time during the narrow interval between vertical pulses. A whole vertical pulse will always appear at the beginning of the group of six. The negative output of the mixer (42) is applied to the sync mixer and clipper (47) from which it is fed to the common load resistor of the two stage clipper (18) where it is combined with the other portions of the composite wave. In the second stage of the clipper (18) a peaking coil is used to steepen the edges of the pulses. This signal is fed from the clipper to the line amplifier (36). A positive RMA synchronizing signal is available from the cathode through coaxial connector and a negative signal is also available from the plate of this amplifier tube through another coaxial connector.

The whole function of this sync generator is to provide the interim signals transmitted while the useful video signal is not effective. The picture that appears on the screen of the monitor tubes and on the screens of the television receivers under test must be added with other equipment, either from a regular camera focused on a test pattern or from a monoscope—a special tube that has a pattern printed permanently on its mosaic.

Other accessories would consist of a sufficient number of line am-



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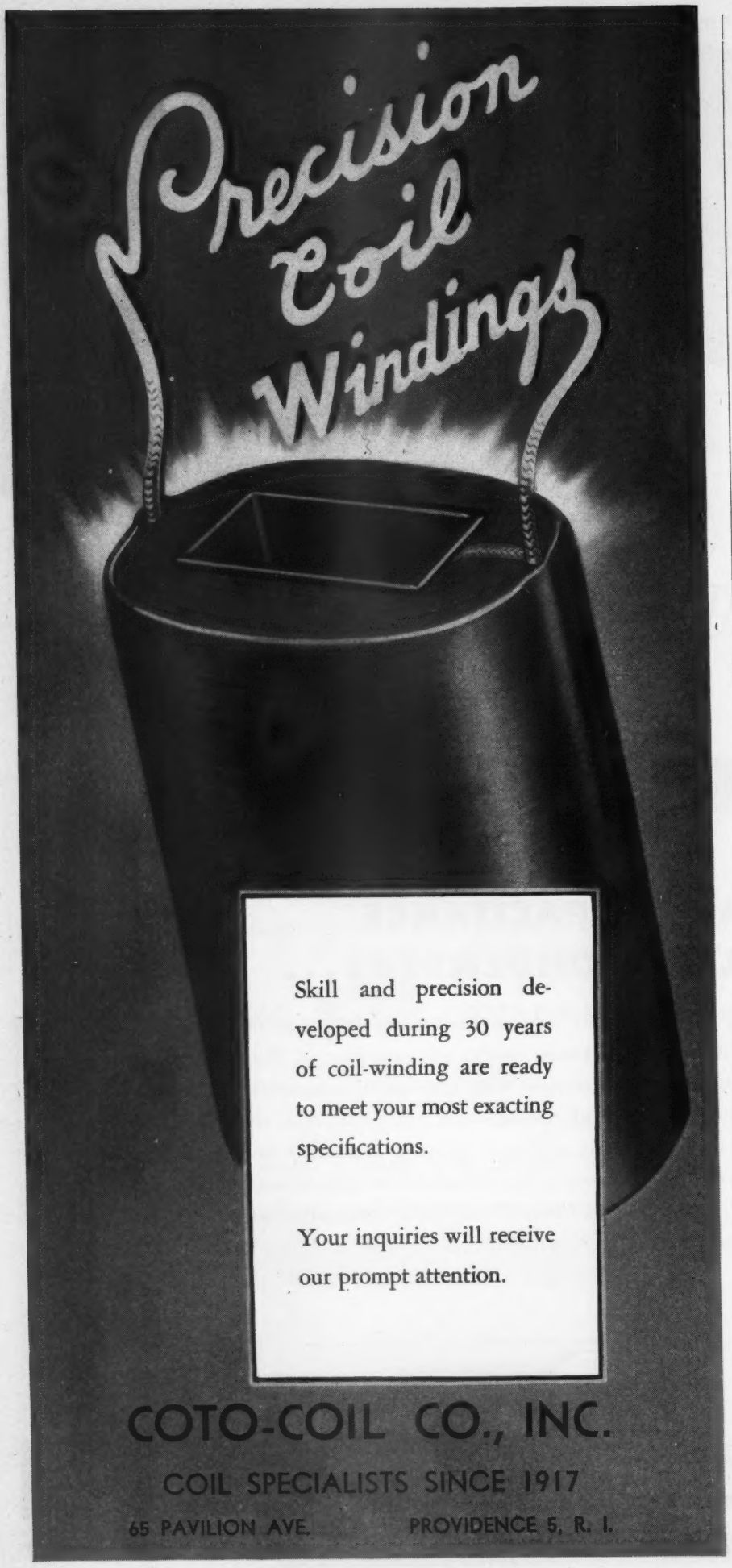
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plifiers having capabilities for handling the wide range video signals, to distribute the composite signals to the test benches and to the other points where they are needed.

Typical designs of such equipment will be described in Part II in the next issue.

BROADCASTING OVERSEAS

(*Continued from page 58*)

It should also be said that in several countries programs are not only distributed by radio but also by wire. From 8 to 10 million listeners in Europe do not have radio sets, but only loudspeakers connected by cable to relay exchanges. There are 120,000 subscribers to wire broadcasting services in *Switzerland,* 350,000 to 400,000 in the *Netherlands,* and 600,000 in *Great Britain.*

In one country, *Soviet Russia,* most of the listeners receive their (pre-selected) programs from relay exchanges; in 1940 already 6,110,000 licenses—i.e., 60% of all licenses—were issued for the use of loudspeakers. This percentage probably is higher today, owing to wartime destruction and enforced Government control of radio reception. Wire broadcasting is also being more and more developed in *Poland* and *Eastern Germany,* where an increasing number of relay exchanges is being installed; loudspeakers are set up in hundreds of communities in order to insure the reception of programs by people deprived of radio sets.

The present state of radio broadcasting is illustrated by the accompanying tables and large chart supplement. Based on personal research as well as on reliable private and official information, they include the latest available data on broadcasting stations and radio sets.* Since the statement of the number of transmitters and receivers alone does not provide a complete picture, it is supplemented by the figures for the total power

*Besides the broadcasting stations included in the lists there are numerous transmitters established on a temporary basis and operated by military authorities and radio services of the armed forces or by political groups fighting the legally established governments. Most of them, however, have no considerable power—there are many with 50 watts and even less—and quite often neither the power nor the frequencies are reported.

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COMMERCIAL PR Type Z-1	Frequency range 1.5 to 10.5 MC. Designed for rigors of all types of commercial service. Calibrated .005 per cent of specified frequency. Weight less than ¾ ounce. Sealed against moisture and contamination. Meets FCC requirements for all types of service.
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of the stations and the density of sets.

The "density", i.e., the number of sets per thousand population, indicates the importance of radio in a particular country. Although the United States holds the first place in this respect, too, several other countries with large numbers of sets do not rank as high as some of the smaller ones, as, for example, *Sweden, Denmark* or *Iceland,* where radio has become a "household utility".

New stations are being established each month, each week, many of them in areas which up to this date never knew radio broadcasting. Vast regions are also opened up by the general trend towards increasing the power of the existing stations, and the tremendous development in the short-wave field.

But this improvement on the transmission side will be of limited value unless the radio industry can satisfy the immense need for new receivers — in all the countries where millions of sets have been destroyed and in those where the density does not even reach one hundred sets per thousand inhabitants. And with the exception of the U.S.A. and *Australia,* almost nowhere do listeners have more than one receiver.

Europe alone needs at this moment about twenty million sets; an official French estimate even figures out "at least fifty millions". In spite of the increased production in *England, Sweden, Switzerland* and *Russia,* in spite of the resumption of industrial activities in *Holland, Germany* and *Japan,* these millions of sets have to be produced by and shipped from the United States, which leads the world in radio manufacturing.

1947 Broadcast Engineering Conference is Cancelled

Plans for holding the 1947 Broadcast Engineering Conference, sponsored annually by the Departments of Electrical Engineering at the University of Illinois and Ohio State University, have been cancelled. Crowded conditions and lack of sufficient personnel at both universities made the cancellation necessary, although it is expected the event will be resumed in 1948.

MULTI-CHANNEL RADIOTELEPHONE

(*Continued from page 77*)

In this part of the radio frequency spectrum adjacent channels are 8 kc apart, consequently some compromise must be made between selectivity and sideband attenuation. The following intermediate frequency amplifier selectivity characteristic was worked out to give adequate adjacent channel attenuation with a minimum sacrifice in voice intelligibility.

Ratio	*Band Width*
20 db	11 kc
40 db	17 kc
60 db	24 kc

Typical image rejection is approximately 6000/1 at a receiving frequency of 2738 kc and 1200/1 at 6455 kc. Delayed avc is used so that the output voltage remains constant within approximately 4 db when signal input at the antenna varies from 10 microvolts to 1 volt. Maximum undistorted audio-output is 1 watt and the frequency response of the audio system is substantially flat from 200 to 3500 kc.

Negative feedback is used to flatten the frequency response and at the same time minimize the mismatch which occurs when three receivers are connected to one loudspeaker at the same time. A series type noise limiter adjusted to clip at approximately 75% modulation is incorporated in the receiver. Antenna transformer primaries of the six receivers are permanently connected in parallel to the antenna. At any of the operating frequencies a 30% modulated signal of less than 10 microvolts at the antenna terminal will produce 50 milliwatts output at the loudspeaker terminals.

When a call is inaugurated by the shore station, the operator dials an ordinary telephone dial and 600 cycle and 1500 cycle tones alternately modulate the shore station carrier.

Incorporated in the selective ringer are filter circuits resonant at these frequencies. The output of these filters is rectified and impressed on a polarized relay, the contacts of which alternately discharge a resistance capacity net-

(*Continued on page 149*)

ATTENTION
INSTRUMENT
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Conant designs and laboratory production methods permit the production of special rectifier assemblies at regular prices.
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Your specifications must contain the following information:

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2. **The maximum inverse current per disc.**
3. **The ambient temperature at which above values are to be measured.**
4. **A definite statement of the method used to make the above measurements and a schematic of your test circuit.**

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work through the field coils of a selector relay.

The armature of the selector relay is mechanically linked to a code wheel in such a manner that the code wheel notches up one step for each impulse received from the polarized relay. This code wheel has 23 holes located around its periphery and removable pins are inserted in certain of these holes depending upon what telephone number has been assigned to the vessel.

Thus if, for example, the first digit of the vessel's telephone number is 4, a pin is inserted in the fourth hole. When the shore station dials 4, the selector relay notches up four positions and an arm on the relay swings out and catches the pin, preventing the wheel from returning to zero. As the other digits are dialed, the code wheel will continue to notch up, provided pins have been inserted in the proper holes. On the 23rd impulse the wheel closes the bell ringing contacts.

The gain of the ringer amplifier is adjusted so that the selective ringer will operate on any of the three high frequency channels with a 50% modulated signal of three microvolts input. Extreme atmospheric noise will tend to notch up the code wheel and make the ringer inoperative. However, it has been found in practice that if the signal to noise ratio of the signal from the shore station is high enough to allow the placing of a "commercial" call, the ringer will operate satisfactorily.

Raytheon Radar Goes on 10 Ships

Installation of 10 mobile radar units aboard as many vessels was approved by the FCC late in December. In all cases Raytheon equipment will be used. The Commission also received six applications for shipboard radar units.

TV Section For Navy

The U. S. Navy now has a television division in its radio section. It will be known as the Radio-Television Section of the Navy Office of Public Information. It is headed by Commander Harry Holton.

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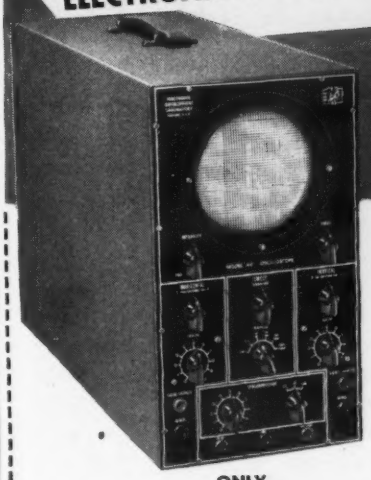

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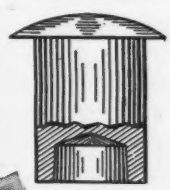

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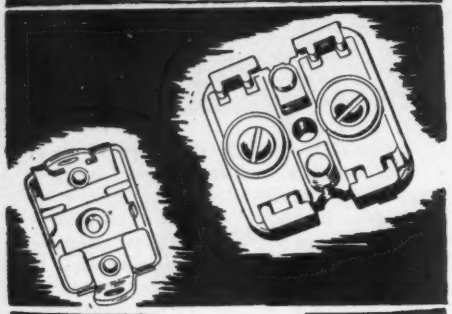

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RAILROAD COMMUNICATIONS

(*Continued from page* 83)

its FM inductive communication equipment on the Seaboard Airline. The right-of-way covered a distance of approximately 162 miles and the terrain was generally hilly, the tracks passing through many cuts and fills. The wayside equipment was directly coupled to the wayside wires while the mobile equipment was inductively coupled by means of a loop antenna. A satisfactory range of 50 miles was obtained with this type of equipment although distances up to 125 miles were reported with satisfactory communication. The wayside equipment was the Aireon FM Model 512-A at a carrier frequency of approximately 170 kc. This particular equipment is voice controlled eliminating a manual "transmit-receive" switch.

Microwave Experiments

A number of equipment manufacturers and railroad companies are conducting experiments in the use of microwave radio frequencies for railroad operation. During March of 1946 the Chicago-Rock Island & Pacific Railroad conducted several tests of end-to-end communication on microwave frequencies in conjunction with the Sperry Gyroscope Co. The Sperry transmitter was operated on a frequency of 2660 mc with a power output of 1 watt. The receiver output, fed into a recording device, showed rapid fluctuation and attenuation in tall building areas. However, the point of minimum signal did not extend into the area of receiver noise.

The Denver & Rio Grande Western has also conducted tests with frequencies in the ultra-high band. In this case a Sperry phase modulation 15 watt experimental unit operating at 2600 mc was used for end-to-end communication on a run between Denver and Salt Lake City. No extensive results are available but it is reported that no flutter or distortion was apparent. Fading, however, was registered on the meter and in a few cases the signal dropped low enough to lose AVC control. At this higher frequency of operation the importance of reflected surfaces becomes para-

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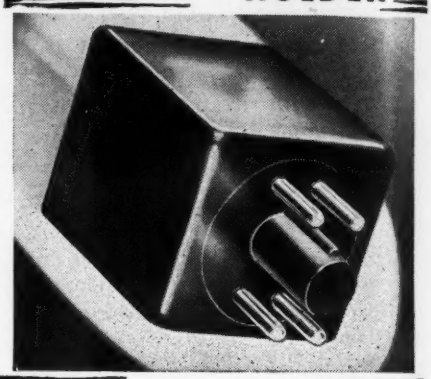
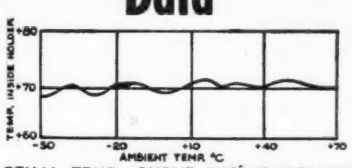
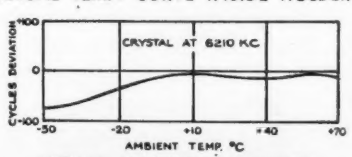


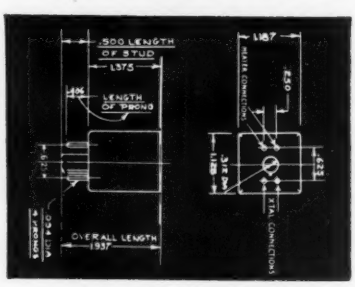
Performance Data



ACTUAL TEMP. CURVE INSIDE HOLDER



ACTUAL FREQUENCY CURVE



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mount. When running on the side of a mountain or in a straight tunnel, for example, the high frequency signal attenuates rapidly until the train moves into a vicinity where reflecting surfaces will help the signal along.

Radio Telephone Service

The Southern Pacific Railroad Company in conjunction with the Pacific Telephone & Telegraph Co. conducted a series of space radio tests in the San Francisco Bay area using a mobile telephone service. A standard selecting mechanism on each mobile unit picked up the selective dialing tone from the main stations and engine crews were alerted by a large bell and a red lamp on the local unit. To establish contact with the operator, the mobile unit handset was removed from the hook and a button pushed for about ten seconds. This provided a service similar to that supplied by a local telephone drop, the only difference being in the push-to-talk feature of the mobile handset.

The service was reported as very satisfactory and useful in switching operations. Solid coverage was experienced throughout the entire yard area which extends over approximately 12 miles of switching tracks. The main transmitter receiver installation in San Francisco was tied into the telephone company PBX and remote receivers were also connected into the network by means of telephone lines. All space radio transmission from the local telephones to the mobile units was made through a 250-watt transmitter in San Francisco. Transmission from two mobile units was picked up by the most favorably located receiver depending on the location of the mobile unit, and relayed to the main PBX in San Francisco. The remote receivers were located in San Carlos and East Oakland.

At least one company is manufacturing radio equipment to improve the present centralized traffic control in railroad operations. The Airplane Marine Instrument Co. is currently engaged in tests with radio inductive equipment set up on a large eastern railroad. As distinguished from the conventional system, this new type of radio traf-

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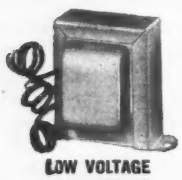

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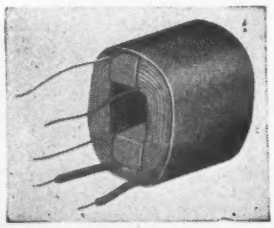

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(*Continued from page* 151)

fic control is based on a keyed radio carrier which operates coded relays along different sections of the line. Each section is assigned a different carrier frequency and instantaneously telemeters the switch setup in any block back to the dispatcher's office. Preliminary experimental tests using this type of centralized traffic control are considered satisfactory and preparations are now under way to install this equipment on three additional runs. This constitutes one significant application of radio to railroad signalling.

Mobile Antennas

Experiments have been conducted with numerous types of mobile antennas because of the new demands that railroad types of operation imposes on this link of the radio system. [A number of different types of fixed station antennas have been used including the half-wave, vertical "J", the square corner reflector, the horizontal rhombic, the coaxial vertical and the biconical antenna.] After considerable tests on mobile antennas, the trend seems to be in the direction of the ground-plane type for space radio use. This type combines small dimensions with satisfactory transmission and reception qualities.

For mobile equipment Bendix uses a broadband, vertically polarized, non-directional type of antenna based on the wheel and spoke ground-plane type. Westinghouse has used the ground-plane quarter-wave antenna. For induction service, Aireon uses an induction loop consisting of weatherproof wire wound on a frame of large horizontal dimensions, and mounted in such a way as to provide maximum coupling between the loop and wayside wires.

For fixed station antennas, Farnsworth uses a vertical colinear array and Westinghouse uses a coaxial type of half-wave antenna. Bendix has experimented with the biconical antenna of two half-wave cone shaped wire cages mounted vertically on high structures. For the inductive type of service Aireon has coupled their wayside installation directly to wayside wires.

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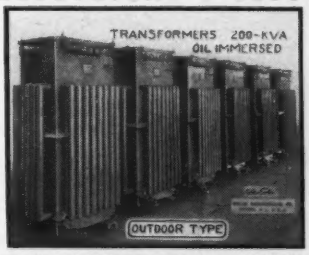

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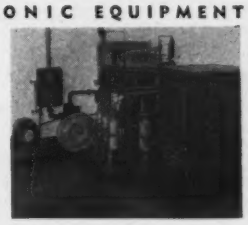

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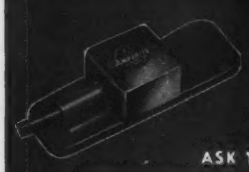

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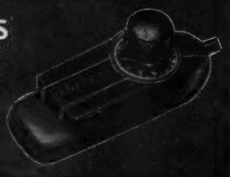

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U.N. SOUND SYSTEMS

(*Continued from page 93*)

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Western Electric saltshaker Model 633 mircophones are used at Lake Success, and are equipped with a special shock absorber mounting. It was determined from actual operating experience that certain delegates given to persistent table pounding and moving the microphone made the consequent noises objectionable; hence the specially designed shock mounting. Cannon connector plugs, Daven gain controls, Weston VU meters, Jensen loudspeakers, and Western Electric keys, jacks and patchcords are used throughout the entire system.

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The results of extensive frequency, distortion and noise measurements with an output volume level of plus 18 VU (10 db above normal program levels) have demonstrated that the UN sound system is well within the limit prescribed by the FCC's standards of good engineering practice for FM broadcasting.

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The Du Mont television network has been granted the exclusive right to televise the home games of the Yankee Baseball club and the home games of the New York Football Yankees. This will make a total of 77 baseball games, and seven football games. Du Mont also plans, facilities permitting, to bring New York fans 11 Yankee games to be played each in Washington, Boston and Philadelphia.

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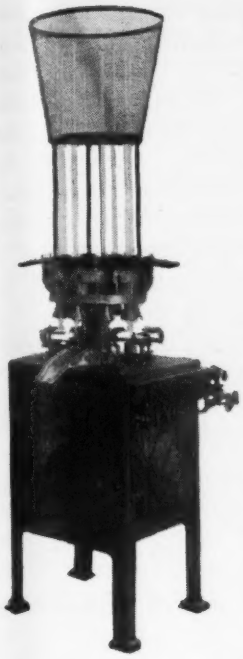

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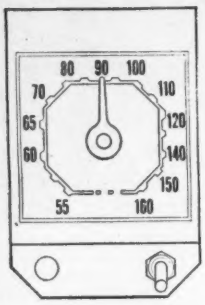

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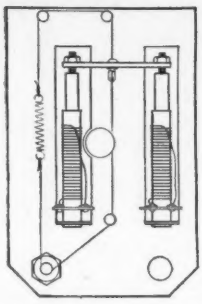

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METALLIZED CAPACITORS

(*Continued from page* 100)

working voltage at increased operating temperatures. Therefore, two working voltage ratings are shown for Solite capacitors — room temperature WVDC and maximum temperature WVDC. This latter rating must not be exceeded under service conditions. Otherwise, excessive breakdowns may result, causing a lowering of both capacitance and insulation resistance.

The following table showing the characteristics of Solite metallized paper capacitors of the two most common voltage ratings will be of interest to circuit designers and specification engineers.

DC Working Voltage 25C	70C	1 Min. Flash Test (Room Temp.)	Sparking Voltage (Room Temp.)
200	150	300	325
400	350	525	750

Where mineral oil impregnation is used for 85°C operation, the dc working voltage at that temperature will be 50% of the 25°C normal working voltage rating.

Insulation Resistance

The minimum insulation resistance of single-layer lacquered metallized paper capacitors will exceed 500 megohm-microfarads at 25°C. Only lacquered paper is used in single-layer designs since omission of the lacquer treatment drops the I-R to 100 megohm-microfarads. Interleaved unlacquered metallized paper capacitors will have a minimum insulation resistance of 1000 megohm-microfarads, which compares favorably with conventional capacitor designs. The change in insulation resistance with temperature in metallized paper capacitors is similar to that in the usual mineral oil designs. Roughly speaking, there is a 50% decrease in I-R for every 10°C rise above room temperature.

Metallized paper capacitors show an extremely low power factor, both at 60 cycles and at 1000 cycles, averaging about 0.3% at room temperature, due to the combination of non-inductive winding, the short length of section inherent in metallized paper construction, and the use of hydrocarbon waxes or oils as the impregnating medium, cou-

pled with the dry-assembly process of manufacture.

The short length of section plus the excellency of the terminal film connection, results in an extremely low rf impedance for Solite capacitors and self-resonant frequencies considerably higher than that hitherto approached by conventional designs.

The life testing arrangement for metallized paper capacitors resembles that for dry electrolytics. A choice of 1.25 times the working voltage for life test voltage was made to assure there was an ample factor of safety used in establishing the working voltage with reference to the sparking voltage.

Solite metallized paper capacitors are a new departure in capacitor manufacturing technic. A homogeneous aluminum film of negligible thickness deposited on the dielectric replaces the conventional foil and permits operation at higher dielectric stresses without fear of permanent short circuit because of the self-healing characteristics of the film. The resultant capacitors, (1) are extremely small in size; (2) have long life; (3) have low power factor; (4) have excellent rf characteristics; (5) are interchangeable with present standard capacitor designs when operated within published ratings.

Contract Signed By Television

A two-way coaxial cable on a closed television circuit permitted the signing of a business contract between Dumont officials in New York and Chevrolet executives in Washington, D. C., on November 18. This new application of video makes it possible for business executives in different cities to discuss the terms of an agreement and simultaneously to sign contracts.

Each group viewed twin television screens, one picturing officials in Washington, the other those in New York. Contracts were signed with a counterpart on each desk. Video cameras were focused from overhead, and the individual counterparts were televised on a monitoring panel in New York, where they were "lapped" to produce one document. Film recorded the picture for permanent record.

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features probe with extremely low input capacity

RANGE: 0.3 to 300 volts r-f in five ranges (3, 10, 30, 100 and 300 volts full scale).
ACCURACY: Better than 2% of full scale on all ranges and sinusoidal voltages.
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Write for Bulletin

ALFRED W. BARBER LABORATORIES
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PERSONNEL

John C. McPherson has been appointed manager of patent research and development for International Business Machines Corp., New York City. He was previously director of engineering, and prior to that head of the company's future demands department.

J. C. McPherson

B. V. K. French

B. V. K. French has been appointed director of field relations at Howard W. Sams and Co., Inc., Indianapolis, where he will act as liaison between the radio manufacturing industry and the servicing profession. Joining Federal Telephone and Telegraph in 1923, he is a veteran in the radio industry, and at various times has been associated with RCA, P. R. Mallory Co., and Case Electric Co.

Charles L. Allen has been appointed motor sales and application engineer for the eastern half of the United States for Telechron, Inc., Ashland, Mass., and **Donald S. Mayo** has been appointed to the timer sales and application engineering department to cover the territory east of the Mississippi for the same company. Both men have been associated with Telechron for several years: Allen has had nine years' experience in the sales and engineering department, and Mayo has been associated with the engineering department for six years.

Robert O. Bullard, formerly superintendent of the carbon products manufacturing division of the apparatus department of General Electric Co., Pittsfield, Mass., has been appointed engineering and manufacturing manager of the metallurgy division at GE. Joining the company in 1930 he has been with various departments, and became superintendent of the GE plant at Ft. Edward, N. Y., in 1942.

Dr. W. A. Johnson, manager of the metallurgical section of the Westinghouse Research laboratories, has been selected to set up and direct a new metallurgical division of the Clinton laboratories at Oak Ridge, Tenn., to study military and peacetime applications of atomic energy. Originally joining Westinghouse in 1939, he has been granted a year's leave of absence for this special work connected with the design of chain-reacting atomic piles.

Henry W. Parker has been appointed technical adviser for Sylvania Electric Products, Inc., Emporium, Penna. The new post has been created to stimulate review of industrial and scientific developments of interest to the central engineering laboratories and to propose new research projects. At present, Parker is cooperating with the U. S. Dept. of Commerce in connection with its study of electron tube development in Germany and Japan during the war.

H. W. Parker A. R. Hopkins

A. R. Hopkins has been appointed manager of communications and electronic equipment sales for the RCA Victor Division, Radio Corp. of America, Camden. Prior to this, he was regional manager of the department for the Chicago area.

Clyde P. Elliott, graduate of the University of Colorado, has been appointed sales engineer for C. P. Clare and Co., Chicago. His territory will include Colorado, New Mexico, Utah and Wyoming, with an office in Denver to be opened in the spring.

Amos H. Carey has been appointed director of manufacturing for John Meck Industries, Plymouth, Ind. He was formerly factory manager for the Sprague Electric Co., and at one time in charge of manufacturing for RCA.

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FREQUENCY RANGE 54 to 216 MEGACYCLES

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VERNIER DIAL—24:1 gear ratio with main frequency dial.

FREQUENCY DEVIATION RANGES—0-80 kc; 0-240 kc.

AMPLITUDE MODULATION—Continuously variable 0-50%; calibrated at 30% and 50% points.

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RF OUTPUT VOLTAGE—0.2 volt to 0.1 microvolt. Output impedance 26.5 ohms.

FM DISTORTION—Less than 2% at 75 kc deviation.

SPURIOUS RF OUTPUT—All spurious RF voltages 30 db or more below fundamental.

Write for Catalog D

This instrument was described editorially in November ELECTRONICS—reprints available on request

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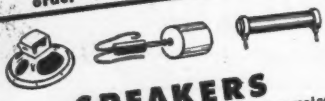
ACORN TUBE SOCKET Low loss ceramic socket with rugged spring contacts for 954 and 955 tubes Minimum order—100 $7.50 Per 100



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5" Alnicko V PM Speaker with 4 ohm voice coil, less output transformer. Minimum order—100 $1.37 ea.
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WIDE READING

(*Continued from page 95*)

charge of an electron, respectively. For an angle of incidence, α, the expression for C_{max} is multiplied by the factor

$$1 \cos^2 \alpha/(1 + H/R)^2,$$

where H is the height of the reflecting layer and R the radius of the earth. This results in a ratio of the shortest wavelengths reflected at horizontal and vertical propagation equal to

$$\lambda_h/\lambda_v = \sqrt{H}/56.$$

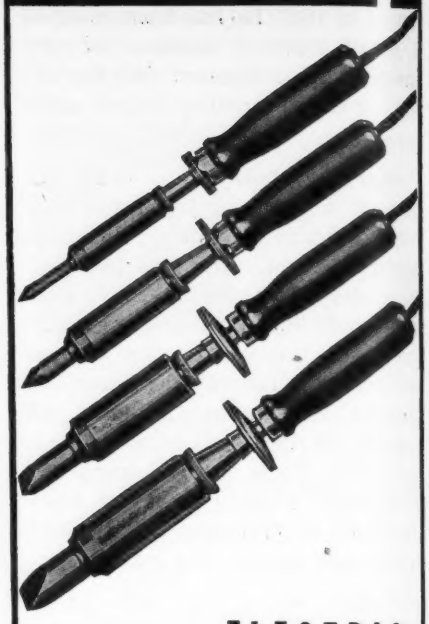
Assuming an F-layer height of 250,000m, the shortest vertical reflected wave will be 60m, while the shortest horizontal reflected wave is only 17m. The wave paths for different angles of incidence, α, are illustrated in the figure. With increasing angle the waves first penetrate deeper into the ionized layer and the distance between sender and receiver decreases (rays 1 to 6). With further increase in angle, the waves follow a longer path inside the high density upper portion of the ionized layer and the distance between sender and receiver increases (rays 6 to 9), these rays spend more time inside the layer and are therefore highly damped. Further waves traverse the layer.

Variations of ionizing layer heights and densities with day and night, summer and winter, sun spots, northern lights, etc. are reported and the resulting effects on wave propagation explained. Systematic observation and study of ionospheric conditions permit radio weather forecasting.

Moscow Communications Meet

The next world telecommunications meeting is to be held in Moscow on July 1, this year. This much was decided at the Telecommunications Conference held in the same Russian city and recently closed. At the same time it was decided that a World High Frequency Broadcasting Conference will be held in the Fall of next year. At the July 1 Conference it is expected that the Madrid conventions will be revised and that an entirely new structure for the International Telecommunications Union will be set up.

American Beauty



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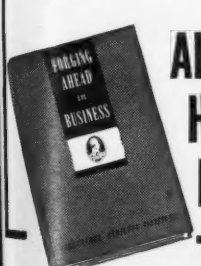

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NEW BOOKS

Metallized Paper Capacitors

Published by the Office of the Publication Board, Department of Commerce, Washington, D. C., reproduced with permission by Hobart Publishing Co., Washington, D. C., 50 pages, 8 illustrations, $3, 1946.

The German manufacturing methods of producing metallized paper capacitors made by Bosch are described. Details of the composition and properties of the materials used and of the manufacturing processes involved are given. Research and testing facilities are discussed and performances of the finished capacitors are tabulated.

Fundamentals of Electrical Engineering

By F. H. Pumphrey (GE Co.). Published by Prentice-Hall Inc., New York (1946)—367 + XIV pages. Price $5.35.

A preliminary textbook, mainly for non-electrical students, technicians and operators, covering the basic principles and practical applications in the various fields of industrial electricity. Emphasis is placed on basic concepts of many of the commoner electrical machines and instruments are used, including two chapters on electron tubes. Other chapters describe industrial processes such as welding, heating, illumination, industrial control methods, measurements and motor applications.

Marine Technical Group

Late last year a new technical advisory group for electronic marine and navigation problems was formed and it is planned will function much after the manner of the present Radio Technical Commission for Aeronautics. The gathering was brought together by the State Department with its chief of the Telecommunications Division, Francis Colt de Wolf, presiding. The group will advise on matters of allocation of marine frequencies and the standardization of equipment.

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Rochester Meeting

Television came in for greatest attention in the business of investigating the latest developments in the communication art at the Rochester Fall Meeting of the IRE-RMA Engineering division on November 11-13. As this has been the custom for the past 18 years, these technical sessions, attended this year by 800 engineers, have been devoted to more or less informal disclosures of new principles and technics that have important bearing on the radio communication industry. At the same time, over twenty of the technical committees of both sponsoring organizations met in joint sessions, to discuss the problems and arrange standardized procedures.

The twenty technical papers presented during the technical sessions were delivered in a manner that is intermediate between the short 10 minute summaries that are the rule at some technical meetings and the long one speaker-per-session papers that are so common at others.

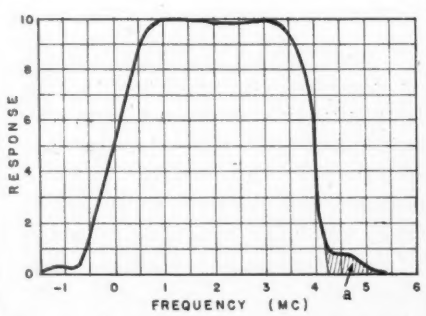

Fig. 1—Shaded portion shows modification of video IF curve to include sound spectrum (Dome-GE)

A new arrangement for separating the video and audio channels in a television receiver was disclosed by R. B. Dome (GE) in a circuit simplified by eliminating the sound IF channel entirely. It also makes receiver tuning easier by making exact tuning of the local oscillator unnecessary, and reducing the effect of local oscillator drift. Advantage is taken of the fact that the video carrier, being AM, has a fixed frequency, whereas the FM sound carrier varies up and down in frequency. The difference frequency between the two carriers represents a signal that contains all of the audio signal.

In the system disclosed, the video IF response band is extended

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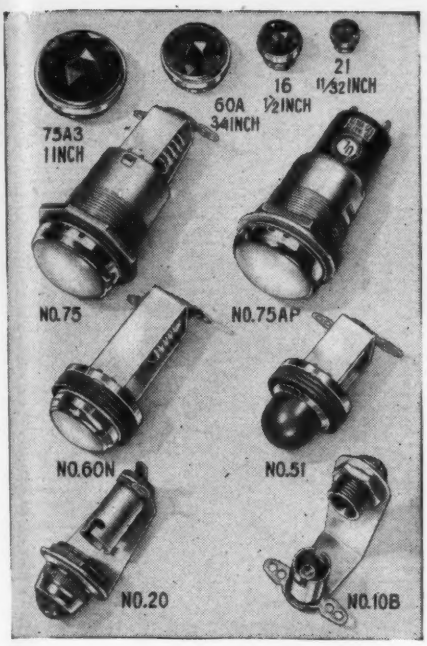

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slightly to include a certain amount of signal at the 4.5 mc point, as in Fig. 1. The regular picture IF and second detector system therefore becomes a combined picture-sound channel. As shown in Fig. 2, a simple 4.5 mc double-tuned transformer (2-5) in the video amplifier circuit picks out the sound signal,

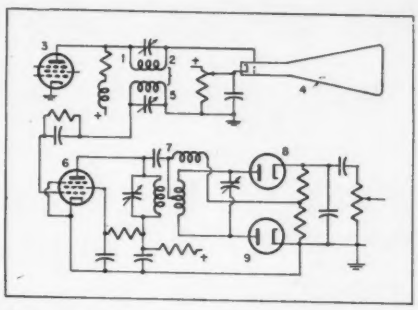

Fig. 2—New audio signal separation method uses common IF amplifier channel (Dome-GE)

and applies it to a standard FM limiter tube (6) and discriminator circuit (7). The 4.5 mc resonance transformer (2) operates in series with the regular capacitive load imposed by the modulation grid of the picture tube (a few thousand ohms at this frequency).

This system imposes a requirement on transmitters to maintain constant picture carrier, but this is now being done at all New York stations anyway. The feature of eliminating the usual disturbing effects of receiver local oscillator drift is distinctly an improvement. In addition, circuit simplicity is attained, especially where the double load of the first detector is avoided, permitting higher IF gain. One or more tubes, usually provided in the sound IF channel, are eliminated.

A review of recent television improvements was discussed and demonstrated by G. L. Beers (RCA-Victor) with the complete installation of television pickup facilities with both direct viewing and projection receivers, the former producing pictures with a 60-ft. lambert highlight brilliance with a contrast range of from 70 to 90: 1, with a Kinescope operating at 9 KV. The Image-orthicon with a 100-fold increase in sensitivity, the 6500-7050 mc relay system with high directivity reflectors (2° and 3.2° beam with 6 ft. and 4 ft. diameters) and numerous circuit details were discussed. A paper by R. F. Guy (NBC) summarized the effects tele-

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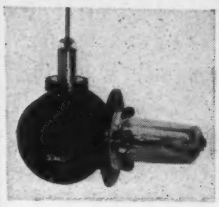

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KLYSTRON oscillator tubes 2K25/723ab, designed for 3 cm. operation. New. Packed individually. Listed at $38.00, reduced to.. 7.75
1B24 TR tube (3 cm) 2.98
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30 mc oscillator-amplifier with 2 6AC7's. Uses 723ab, Waveguide input, xtal detector.
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PLATE TRANSFORMER! 115 v. 60 cycle primary. 6200 volt-ct-700 mil secondary. Size 11"x14"x10" $39.95

½ WAVE RECTIFICATION TRANSFORMER. 115v-60c/3200v @ 150 mils. MADE BY KENYON $9.95

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12hy-12 hy @ 150 ma., 15 amp. rating, each price $4.25
15 hy @ 165 ma 200 ohms DCR. Price.... 2.00
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2.6 hy @ 800 ma stud and terminals at bottom 7.95

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Sockets for 5CP1; 3BP1, and similar types of tubes $.95

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vision service will have on public habits.

The remainder of the sessions were largely devoted to the analysis of new components in widely diversified fields—electronic reproducer pickups and microphones (H. F. Olson) (Fig. 3), powdered iron tuning methods (Polydoroff), metallized paper capacitors (Cornell), applications of subminiature tubes, and of selenium rectifiers.

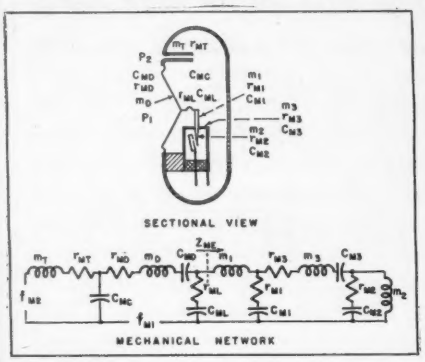

Fig. 3—Electronic microphone uses variable impedance of diode as active element. (Olson-RCA)

In the field of measuring technics, papers were presented by H. W. Lamson (General Radio) relating to the measurement of ferromagnetic characteristics that are of interest at communication frequencies, and by D. M. Hill (Boonton Radio) on a new FM signal generator.

Two evening sessions were devoted to popular talks—a review of the problem of investigating the war inspired inventions (?) of death rays, by Dr. A. F. Murray, and a description of recent developments in color photography by A. L. TerLouw, provided highly interesting diversions from the deeper technical papers.

The engineering development of a high frequency amplitude modulation broadcasting station for small communities was described by Sarkes Tarzian. A pilot installation has been made at Bloomington, Ind., and tested as to coverage. A simple frequency converter was found adequate to permit picking up the 108 mc signals on an ordinary AM receiver. It was shown that there are hundreds of localities where such stations serving community interests would be of value. A paper by M. G. Nicholson compared the characteristics of AM and FM as to noise reduction in broadcasting.

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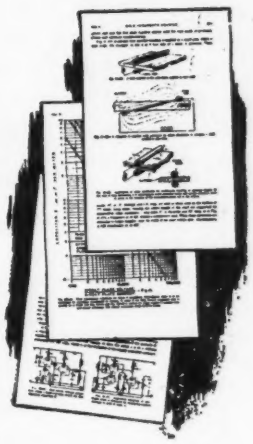

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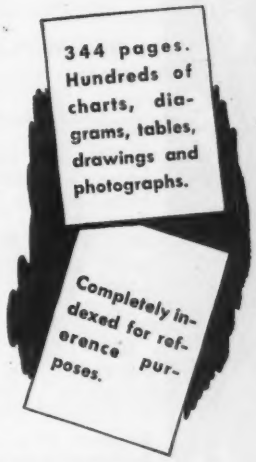

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- Chapter 5—*Passive Networks*
- Chapter 6—*Error Detectors*

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- Chapter 3—*Saturable Reactors*
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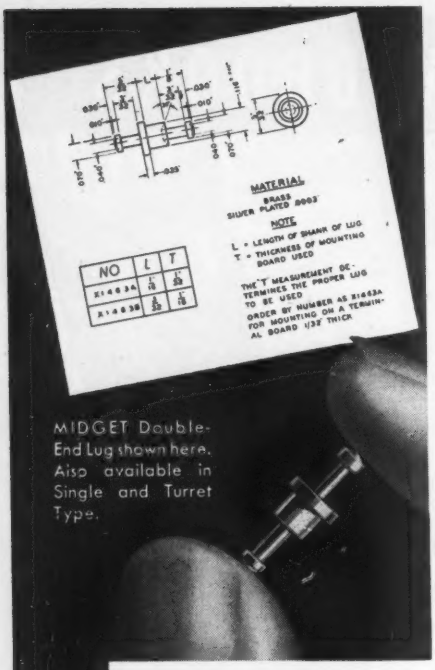
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Facsimile Broadcasts From 12 Cities Seen

Spearheaded by WGHF, New York, pioneer FM and facsimile station, which has been broadcasting "Air Press" daily, facsimile broadcasting on FM channels will begin early this year from 12 or more cities, according to Capt. W. G. H. Finch, president of Finch Telecommunications, Inc., Passaic, N. J. Cities in which facsimile service to homes in their service areas is scheduled include: New York, Chicago, Detroit, Los Angeles, San Francisco, Cleveland, and San Bernardino, Calif.

With production of both studio transmitting and home receivers now being planned, it is anticipated that facsimile broadcasts over FM facilities will soon take its place in millions of homes alongside radio broadcasting as a medium of public entertainment and education. Facsimile programs are now being broadcast over WGHF on 99.7 megacycles and carry for a radius of about 60 miles. Prior to the war, Finch had licensed 15 major broadcasting stations to transmit facsimile over AM facilities. Transmission is now by FM, with greatly improved fidelity of reproduction and freedom from atmospheric disturbances.

Jefferson-Travis to Emerson Radio

Jefferson-Travis Inc., New York, pioneer manufacturer of marine radio and radiotelephone equipment, has become a wholly owned subsidiary of the Emerson Radio and Phonograph Corp. The J-T corporation is operating as a separate unit, maintaining its own laboratory and production facilities and is planning large expansion in radiotelephone, portable radio and other marine radio equipment. Robert C. Berner, an Emerson officer, has been elected president of the subsidiary company. Colonel Harold H. Lloyd, formerly director of special products division of Emerson, has been appointed general manager. A. L. Plager, former director of contract termination of Emerson is secretary and treasurer. Joseph Mas has been appointed chief engineer.

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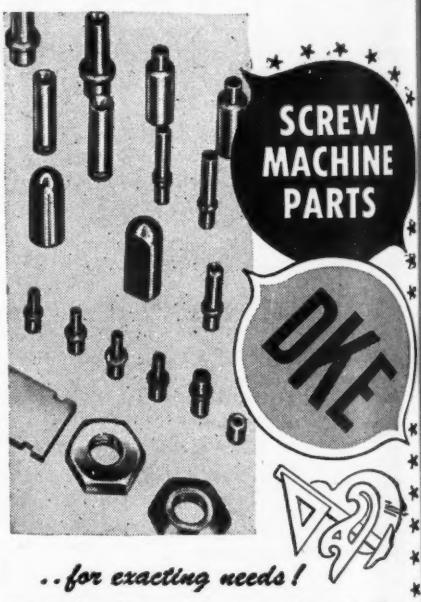

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Dr. A. F. Murray Joins Tele-Tech Staff

Dr. Albert F. Murray of Washington, D. C., who has been appointed consulting editor of *Tele-Tech,* has had wide experience in radio, communications and television. Graduating from Massachusetts Institute of Technology and Harvard, he served as research engineer with

Dr. Albert F. Murray

Dr. A. E. Kennelly and John Hays Hammond, Jr., later joining forces with General Radio Co., Wireless Specialty Apparatus Co., and Raytheon Mfg. Corp., all in the Boston area. His television work began with Jenkins in 1929, and during the next ten years he was in charge of television research first for RCA-Victor and then Philco. Since 1940 he has been a consulting television engineer with the Howard Hughes television interests as one of his clients.

During World War II he served with the National Defense Research Committee, on special radio work, later heading up its Guided Missiles division. Dr. Murray is a Fellow of the IRE, a member of many engineering bodies, and has served from the beginning on the television panel of the Radio Technical Planning Board. His Washington address is 4707 Windom Place N. W., Washington, D. C.

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SOUND RECORDING EQUIPMENT

Professional sound recording and playback equipment is described fully in a loose-leaf catalog issued by Fairchild Camera and Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y. Detailed specifications, performance curves, dimensional data and illustrations are given for studio and portable recorders, a transcription turntable, amplifier-equalizer, magnetic cutterhead, and lateral dynamic pickup. Also described is the "language master" playback machine which permits accurate location and repetition of any part of the record.

SPECIAL PRODUCTS DATA

A number of new data sheets issued by General Electric Co., Schenectady, N. Y., bring the Special Products Handbook up to date with the latest developments. Affected by revisions and new data are the sections on permanent magnets, apparatus to measure strain, force and tension, color and optical equipment, testing equipment for wire, coils, insulations, gas, and materials, and equipment for chemical analysis. Of special interest are the new dew point recorders, the magnetic comparator, insulation resistance meter, and colorscope.

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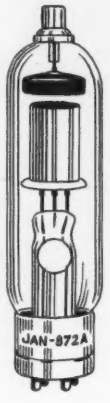

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POWERS, NUMBERS, POPULATION DENSITIES, RATIOS OF BATTERY-VS-MAINS-OPERATED SETS, IMPORTS

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Supplement to January, 1947, issue of

TELE-TECH

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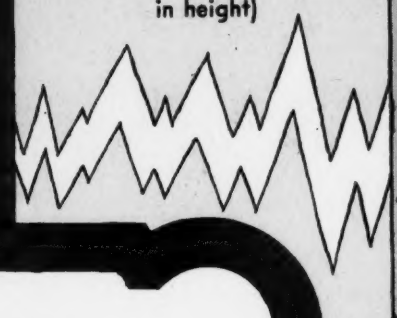
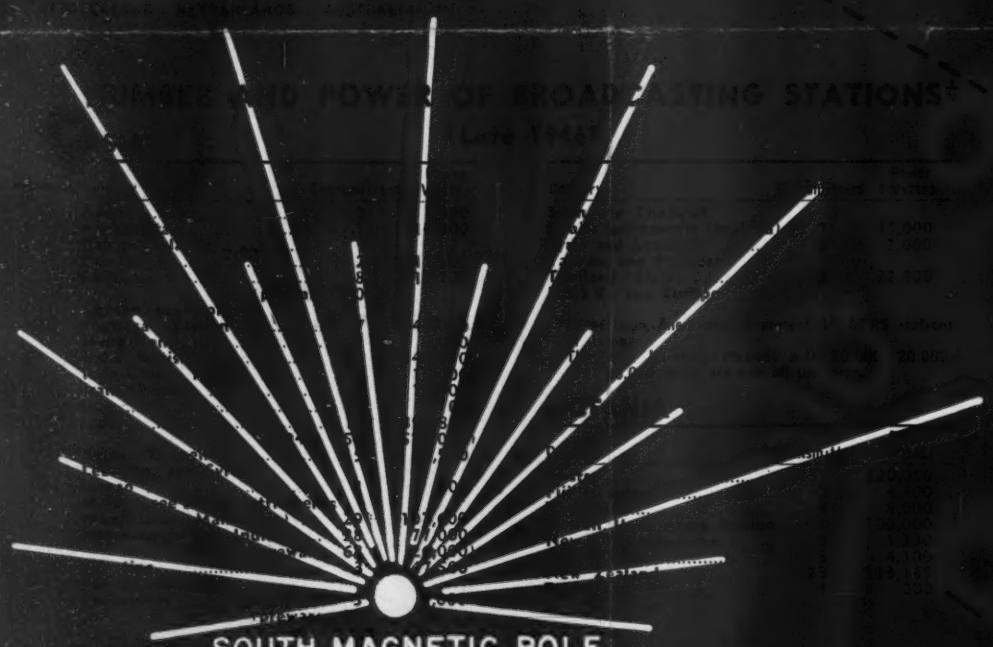


60,000,000
Total Radio Sets in
UNITED STATES



TOTAL NUMBER OF RADIO SETS IN MILLIONS

= DESTROYED BY WAR

CANADA
1,754,351

93.3
1943

193.8 230.1 93.5 27 47 39 152.5 118.1 79.9 425
RADIO SETS PER 1000 POPULATION

14.1 21 14.2 27.3 52.3 29.8 32.1
RADIO SETS PER 1000 POPULATION

37

ASIA AUSTRALIA-OCEANIA SOUTH AMERICA NORTH AMERICA NEAR EAST AFRIC

GREENLAND

N A D A

NORTH AMERICA

UNITED STATES

84%
ED STATES

90%
MEXICO

90%

85%

80%

98%
SWEDEN

80%

85%

99%
DENMARK
GERMANY
SWITZERLAND

95%
CZECHOSLOVAKIA
FRANCE
BELGIUM
LATVIA
NETHERLANDS

90%
AUSTRIA
NORWAY

80%

U.S.S.R. Super

EUROPE

97%

TURKEY

NEAR EAST

85%
EGYPT

EGYPT

80%
ALGERIA ANGOLA
LIBYA MOROCCO MOZAMBIQUE TUNISIA
UNION OF SOUTH AFRICA

ARABIA

AFRICA

75%
RHODESIA

70%
SUDAN

60%
NIGERIA

50%
FRENCH CONGO
MADAGASCAR

45%
BELGIAN CONGO
SOMALILAND

40%

20%

Percentage
Electric-Main Operated
(BLACK—BATTERY OPERATED)

Prewar Total
14,000,000

10% IMPORTED

10,673,000

DESTROYED BY WAR

20% IMPORT

5,500,000
1946

5,576,593

GREAT BRITAIN

GERMANY

FRANCE

DENMARK
1,009,602

820,000

1,148,659

700,000

136.9

CZECHOSLO

1940–1944
167.7—236
varying estimate

99.3
1944

40

1943

50% IMP

117

83.5

99.2

265.4

141

146.7

68 approx.

217

21.9
1946

217.1

59.1

100

110
1946

112.3
1946

35

20.8

4.9

32.7

RADIO SETS PER 1000 POPULATION

FRICA

EUROPE

WORLD-WIDE TELE-COMMUNICATIONS MARKETS

BROADCAST TRANSMITTERS AND RECEIVERS

POWERS, NUMBERS, POPULATION DENSITIES, RATIOS OF BATTERY-VS-MAINS-OPERATED SETS, IMPORTS

Based upon all available wartime and post-war compilations. Sources consulted: Berne Bureau; Geneva Union Internationale; U. S. State Department; Federal Communications Commission; Carnegie Institution of Washington; North American Philips Company; International Tel. & Tel. Corp., and RCA-International.

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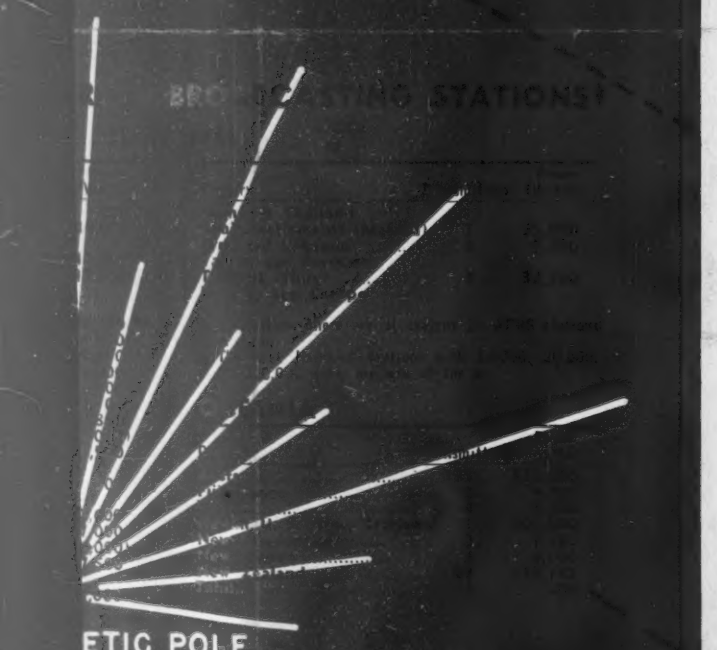
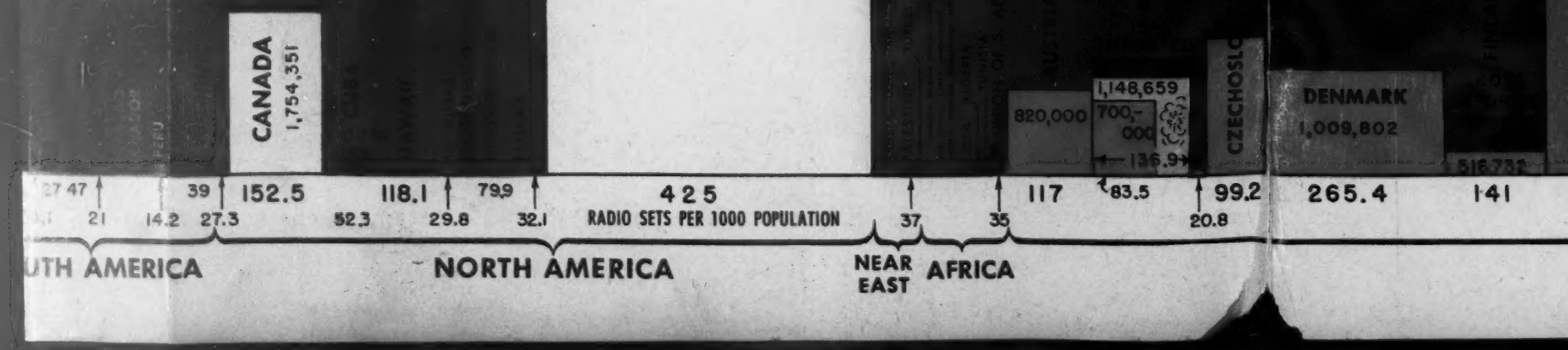


60,000,000
Total Radio Sets in
UNITED STATES



GREENLAND

RUSSIA

U.S.S.R. "Super" BC Station, 2500 KW

EUROPE

98% SWEDEN

80%

85%

99% DENMARK GERMANY SWITZERLAND

95% CZECHOSLOVAKIA FRANCE BELGIUM LATVIA NETHERLANDS

90% AUSTRIA ITALY NORWAY POLAND RUMANIA SPAIN

80% BULGARIA FINLAND LITHUANIA YUGOSLAVIA

? U.S.S.R.

95% PALESTINE

97%

TURKEY

NEAR EAST

IRAN

80%

85% EGYPT

EGYPT

80% ALGERIA ANGOLA LIBYA MOROCCO MOZAMBIQUE TUNISIA UNION OF SOUTH AFRICA

75%

ARABIA

70%

AFRICA

75% RHODESIA

Percentage Electric-Main Operated (BLACK = BATTERY OPERATED)

70% SUDAN

25

EQUATOR

60% NIGERIA

50% FRENCH CONGO MADAGASCAR

45% BELGIAN CONGO SOMALILAND

40%

20

AFRICA

Prewar Total 14,000,000

10% IMPORTED

10,673,000

DESTROYED BY WAR

20% IMPORT

5,500,000 1946

5,576,593

GREAT BRITAIN

GERMANY

FRANCE

1940–1944 ←167.7—236→ varying estimate

99.3 1944

40

1943

50% IMP

50% IMPORTED

1,858,614 SWEDEN

867,365 SWITZERLAND

RUSSIA 10,551,361 – 1940

146.7 | 68 approx. | 217 | 21.9 1946 | 217.1 | 59.1 | 100 | 110 1941 | 112.3 1946 | 5.9 | 14 | 282 | 203.3 | 62.1

RADIO SETS PER 1000 POPULATION

4.9 | 32.7 | 16.6 | 20.9 | 9.2

RADIO SETS PER 1000 POPULATION

EUROPE

C.T. Dreyer